State of Connecticut.

PUBLIC DOCUMENT No 34.

NINETEENTH ANNUAL REPORT

OF THE

STORRS

Agricultural Experiment Station,

STORRS, CONN.

FOR THE YEAR ENDING JUNE 30, 1907.

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CONTENTS.

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STATION STAFF

L. A. CLINTON, M.S.	*Director.*
J. M. TRUEMAN, B.S.Agr.	*Dairy Husbandman.*
C. K. GRAHAM,	*Poultryman.*
W. M. ESTEN, M.S.,	*Bacteriologist.*
C. D. JARVIS, B.S.A.	*Assistant Horticulturist.*
H. L. GARRIGUS, B.Agr.	*Assistant Field Experimenter.*
CHARLES THOM, Ph. D.	*Cheese Expert, Mycologist.*
ARTHUR W. DOX, A.M.	*Cheese Expert, Chemist.*
F. R. THOMPSON,	*Cheese Maker.*
H. D. EDMOND, B.S.	*Chemist.*
CHRISTIE J. MASON, B.Agr.	*Assistant Bacteriologist.*

Publications of the Station

AVAILABLE FOR FREE DISTRIBUTION

The following publications of the Storrs Agricultural Experiment Station are available for distribution, and, as long as the supply lasts, will be sent free to all who desire them.

BULLETINS

No. 25. The Covered Pail a Factor in Sanitary Milk Production.
No. 26. The Relation of Temperature to the Keeping Property of Milk.
No. 28. Dairy Observations.
No. 29. Records of a Dairy Herd for Five Years.
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No. 38. The Marketing of Poultry Products.
No. 39. Pig Feeding Experiments.
No. 40. Creamery Problems.
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Report of the Treasurer.

For the Fiscal Year Ending June 30th, 1907.

The following summary of receipts and expenditures, made out in accordance with the form recommended by the United States Department of Agriculture, includes, first, the Government appropriation of $7,500, and, secondly, the Government appropriation of $2,500 and the annual appropriation of $1,800 made by the State of Connecticut, together with various supplemental receipts. These accounts have been duly audited according to law, as is shown by the Auditor's certificates, copies of which are appended.

GOVERNMENT APPROPRIATION—RECEIPTS AND EXPENDITURES

RECEIPTS.

United States Treasury	$7,500 00

EXPENDITURES.

Salaries	$4,306 62
Labor	1,013 13
Publications	75 69
Postage and stationery	283 86
Freight and express	90
Heat, light, water, and power	53 34
Chemical supplies	299 57
Seeds, plants, and sundry supplies	333 99
Fertilizers	23 13
Feeding Stuffs	401 37
Library	83 46
Tools, implements, and machinery	102 14
Furniture and fixtures	102 96
Scientific apparatus	14 38
Live stock	15 00
Traveling expenses	326 67
Contingent expenses	15 00
Buildings and land	48 79
	$7,500 00

AUDITOR'S CERTIFICATE.

I, the undersigned, duly appointed Auditor of the Corporation, do hereby certify that I have examined the books and accounts of the Storrs Agricultural Experiment Station for the fiscal year ending June 30, 1907, that I have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $7,500 and the corresponding disbursements $7,500, for all of which proper vouchers are on file and have been examined by me and found correct, thus leaving no balance.

And I further certify that the expenditures have been solely for the purposes set forth in the act of Congress approved March 2, 1887.

(Signed) L. J. Storrs, *Auditor.*

Storrs, Conn., July 15, 1907.

ADAMS APPROPRIATION—RECEIPTS AND EXPENDITURES

RECEIPTS

United States Treasury	$3,500 00

EXPENDITURES

Salaries	$2,214 51
Labor	183 23
Chemical supplies	379 52
Seeds, plants, and sundry supplies	236 59
Library	43 89
Tools, implements, and machinery	30 61
Furniture and fixtures	62 40
Scientific apparatus	347 00
Traveling expenses	2 25
	$3,500 00

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And I further certify that the expenditures have been solely for the purposes set forth in the act of Congress, approved March 16, 1906.

(Signed) L. J. STORRS, *Auditor*.

STORRS, CONN., July 15, 1907.

STATE APPROPRIATION AND SUPPLEMENTAL RECEIPTS

RECEIPTS AND EXPENDITURES

RECEIPTS

State of Connecticut	$1,800 00
Miscellaneous receipts	1,657 35
	$3,457 35

EXPENDITURES.

Salaries	$75 00
Labor	769 68
Publications	40 00
Postage and stationery	49 30
Freight and express	158 49
Heat, light, water, and power	102 38
Chemical supplies	14 95
Seeds, plants, and sundry supplies	166 38
Fertilizers	5 60
Feeding stuffs	330 36
Library	7 80
Tools, implements, and machinery	87 00
Furniture and fixtures	73 65
Scientific apparatus	23 98
Live stock	444 00
Traveling expenses	108 75
Buildings and repairs	642 73
Balance	357 30
	$3,457 35

AUDITOR'S CERTIFICATE

I, the undersigned, duly appointed Auditor of the corporation, do hereby certify that I have examined the books and accounts of the Storrs Agricultural Experiment Station for the fiscal year ending June 30, 1906, that I have found the same well kept and classified as above, and that the receipts for the year from the State of Connecticut are shown to have been $1,800, and the receipts from miscellaneous sources $1,657.35, making the total receipts from the State and miscellaneous sources $3,457.35. The corresponding disbursements were $3,100.05, for all of which proper vouchers are on file and have been by me examined and found to be correct, thus leaving a balance of $357.30.

(Signed) L. J. STORRS, *Auditor.*

STORRS, CONN., July 15, 1907.

D. W. PATTEN, *Treasurer.*

Report of the Director

No radical changes have been made in the lines of investigation being conducted by the experiment station during the past year. The additional funds which have been secured from the federal government through what is known as the Adams Act have enabled us to better equip the various departments. Instead of taking up new lines of work, we have endeavored to concentrate the energy of the station workers, believing that in the end we shall thus accomplish most.

CHANGES IN THE STATION STAFF

Several changes have taken place in the personnel of the station staff during the past year. Professor C. L. Beach resigned his position as Dairy Husbandman to accept a similar position with the Vermont Experiment Station. The vacancy thus created was filled by the appointment of Professor J. M. Trueman of the University of Illinois. Professor W. A. Stocking, Jr., Bacteriologist, resigned his position to accept a similar one with the Cornell University Experiment Station. This vacancy was filled by the appointment of Professor W. M. Esten, who for several years has been associated with the station work at Middletown. Mr. Theodore W. Issajeff, who was associated with the cheese experiment work was transferred by the Department of Agriculture to Albert Lea, Minn. His position as cheesemaker was filled by the appointment of Mr. F. R. Thompson. These changes in the station staff have necessarily retarded the station work in those departments.

PUBLICATIONS DURING THE YEAR

Six bulletins have been issued during the year.

Bulletin No. 43, "The Facility of Digestion of Foods a Factor in Feeding."

Bulletin No. 44, "Poultry Suggestions."

Bulletin No. 45, "The Apple Leaf-Miner."

Bulletin No. 46, "Directions for Making the Camembert Type of Cheese."

Bulletin No. 47, "Milking Machines."

Bulletin No. 48, "Comparative Studies with Covered Milk Pails."

These bulletins have been issued in editions of ten thousand each. About nine thousand are required to supply our regular mailing list, and the remainder are kept in reserve to supply requests from time to time.

WORK UNDER THE ADAMS FUND

During the past year the experiment station has received through what is known as the Adams Act $3,500. Our receipts from this fund will increase $1,000 per year until we finally receive $7,500 per year.

Only original, scientific, experiment work can be conducted under the benefits of this fund. At present we are devoting the entire fund to work along the lines of dairy bacteriology, soft cheese investigations in co-operation with the Department of Agriculture, and work in plant breeding especially with beans and sweet corn. All of these lines of work have been approved by the Office of Experiment Stations, at Washington. The exclusive use of the Adams fund for this work has released certain other funds which has enabled us to strengthen the other departments of station work. We must, however, depend upon state aid for buildings and repairs, and for any extension work that may be done throughout the state.

SHEEP HUSBANDRY

The experiment station has purchased from the Perrin estate of Rochester, N. Y., a flock of pure bred Shropshire sheep. These sheep were secured for the purpose of conducting breeding and feeding experiments with the same,

and to get accurate information with reference to the economic possibilities of the sheep industry in Connecticut. Pure bred ram lambs will be sold at moderate prices to those who wish to improve their flocks. The ewes will be carefully selected as the flock increases and only the best will be reserved for breeding purposes.

EXTENSION WORK

The time has arrived when extension work throughout the state should be conducted by the experiment station. From our funds which are now available we can only conduct experiments at the station, publish the results of such experiments in bulletin form and by means of these bulletins and through correspondence and lectures at farmers' institutes, give the results of our work to the people of the state. This is not enough, and the time has arrived when we should conduct demonstration experiments in spraying, in orchard and farm management and we should give direct and personal aid to the dairymen and poultrymen, fruit growers and to any farmer in the state who is in trouble. The demand for us to do this work is becoming more insistent every year. If this work is to be taken up it can only be done through state aid.

DAIRY CONDITIONS

Never have the dairymen of the state faced more serious problems than now confront them. The price of grains has rapidly increased until it is now from 25 to 50 per cent higher than it was one year ago. The price of milk has not increased accordingly, and it is doubtful if it can be generally increased in the same proportion as the price of dairy feeds. In order to meet the present conditions it is necessary for the dairymen to keep individual records of the performance of their cows, that they may know which are the profitable ones and which ones are not paying for their feed. By a persistent and systematic weeding out in the herds, there will come a general improvement in the herds in the state. It is the purpose of our dairy department to give information and assistance to all who wish to improve the quality of their herds.

DEPARTMENT REPORTS

The reports from the heads of the various departments follow. Brief outlines are given of the work which is being conducted by the departments and a careful reading of

these reports is requested. In all departments the work is being conducted harmoniously and with enthusiasm. The station publications are in demand and we believe that the usefulness of the station is being increased each year.

L. A. CLINTON.

Report of the Dairy Husbandman

To the Director of the Storrs Agricultural Experiment Station:

Sir:—During the past year exact records have been kept of the breeding, feeding and production of the dairy herd. The effect of the Burrell-Lawrence-Kennedy Cow Milker upon the yield and quality of milk has been studied. Two years ago the herd was milked by hand. The past year the milking machine has been used. The results upon the yield of milk are not conclusive enough to warrant publishing. A bulletin upon the effect of the machine on the bacterial content of the milk has been published during the year.

Feeding experiments have been conducted for the purpose of determining the comparative value of different grain rations for milk production.

Several of the associations of breeders of dairy cattle have established advanced registries and offered prizes for cows producing a given amount of butter fat in a given time. The associations have called upon the experiment stations of the different states to furnish supervisors when cows are to be tested for these prizes. During the year we have sent out a number of men to supervise tests and have in that way come in contact with a number of prominent breeders throughout the state.

During the coming year experiments and investigations will be carried on concerning the cost of milk production and the best feeds for the Connecticut dairymen to use. The work with the milking machine will be continued. It will require several years to determine definitely the effect of a continuous use of the machine upon the milk flow. The difficulty of obtaining good hand milkers is so great as to

make it important that we determine as quickly as possible the value of the milking machine.

A number of other problems directly connected with dairy interests will be studied, and every effort will be made to make the department of practical use to the dairymen of the state.

Respectfully submitted,

J. M. TRUEMAN.

Report of the Horticulturist

To the Director of the Storrs Agricultural Experiment Station:

Sir:—The investigation work of this department is of two distinct types:—

1. *Demonstration experiments.* The object of this type of investigational work is to solve the various problems which confront the local horticulturist. Of such problems the following have received attention.

(a) Orchard cover crops. Twenty-five different cover crops were tested in a ten acre peach orchard at South Glastonbury. In order to verify the results of last year and to collect further information on the chemical composition of the plants used, it has been decided to repeat the experiment this year.

(b) Orchard renovation. The renovation of a badly neglected apple orchard is under observation.

(c) Spraying experiments. Experiments in the spraying of melons, cucumbers, tomatoes, beans, etc., are being continued. A comparative test was made of the commercial miscible oils and a home-made preparation for the treatment of San Jose scale. The home-made emulsion while apparently just as efficient may be prepared at one-third the cost of any one of the proprietary oils.

(d) A new apple pest. Bulletin No. 45 gives the results of my observations on the habits and life history of the insect known as the Apple Leaf-Miner (*Tischeria malifoliella Clemens.*)

2. *Research.* Under this head comes the solution of the more difficult and fundamental problems in horticulture. Unlike demonstration work the aim of this type of investi-

gation is the discovery of new principles which may not only benefit the agricultural industry of the state but that of the country at large. Investigations of this type may extend over several years and the probable outcome of which is often very vague.

A study of the laws of heredity in plants with special reference to the correlation of characters is being made. For this purpose over two hundred varieties of beans, eighty varieties of sweet corn and eighty varieties of tomatoes are being grown on the station grounds.

Respectfully submitted,

C. D. JARVIS.

Report of the Bacteriologist

To the Director of the Storrs Agricultural Experiment Station:

Sir:—In the change of personnel of the department there would naturally be a change in the lines of investigations. Some former lines of work were discontinued and new lines introduced to take their places. In the transition there may appear a break with less matured investigations to be reported.

The investigations with the bacteriology of cheese have been continued as previously, making a more special study of the conditions which favor the highest efficiency of a lactic acid starter added to milk for the preparation of cheese.

A new line of work is under way in the preliminary study of the fermentation of silage. Some facts have been made out, but nothing definite in reference to the cause of the fermentation. The presence of a yeast in some samples seems to suggest its agency in a part of the fermentations.

The most important investigation going on is determining the sources of bacteria that get into milk. The sources of study have been, surface of the cow, grain and hay. It is interesting to have apparently discovered the source of the most important dairy organism.

The equipment of the laboratory has been very materially increased and many improvements are being added. These facilitate and increase the amount of investigations in a marked degree. The most important for a future addition is a set of steam cookers which will utilize to much advantage the supply of live steam which is supplied to the laboratory during the entire day. Steam cookers not only

save much time but also afford the preparation of a higher grade of culture media than can be obtained by other sources of heat much more expensive.

Studies and compilations are in progress on the subject of pasteurized milk as affecting its food value. Experts who know the most about pasteurized milk are nearly unanimous in the belief that the process is detrimental rather than beneficial. It is demonstrated that the food value is diminished by the process, and further, products seem to be formed which are unfavorable in the process of digestion, especially for young children and infants.

Preliminary preparations are in progress for a study of anaerobic bacteria in milk products. This class of organisms grows without the presence of oxygen from the air. Conditions favorable for them occur in the deeper layers of milk, ripening cream, and interior of cheese. There are certain phenomena which occur in milk products which are puzzling without the activity of some such organisms.

Partial reports will be prepared on those lines sufficiently advanced to admit and placed in this volume. The other lines of investigations will be continued and reported when more complete.

Respectfully submitted,

W. M. Esten.

Report of the Poultryman

To the Director of the Storrs Agricultural Experiment Station:

Sir:—Interest in poultry culture is becoming greater each year, and with this growth of interest comes a greater demand for reliable poultry literature. This forces us not only to take up research work from a strictly scientific point, but also to do a considerable amount of general investigating.

The hopper methods of feeding with an idea as to whether the amount of labor saved is more than offset by a lower production of eggs is being carefully tested, as is also the general physical condition of the fowls and of their offspring.

During the last year a house with a capacity for two hundred hens has been equipped with trap nests. The chicks from the hens in this house are receiving special attention not only as to their future productiveness, but as to their general vitality, taking into consideration the many different conditions under which they are being hatched and reared. It has already become quite noticeable that certain hens produced eggs that would hatch and the chicks would live under the poorest conditions, while with other hens it took much care to hatch the eggs, and more to keep the chicks alive. Again the conditions such as brooders, feed, etc., which appeared favorable for the chicks of one hen had an entirely different effect on those from another hen.

This, and similar work, requires an immense amount of detail both in records and care, and naturally, necessitates the services of competent but expensive assistants. Before last year this would have been impossible, but with the

amount of money now devoted to poultry by this Station, fair results may be expected.

The theory of artificial incubation has had more attention, and a partial report of the work done along this line will be furnished by the Station chemist.

Our greatest handicap in securing good results is lack of suitable buildings. Much of the stock that is being hatched this season, as well as future generations, should be kept at least three years for observation, but this will be impossible with the present buildings.

The investigations in the squab industry are about completed, and the results are practically ready for the printer.

Respectfully submitted,

C. K. GRAHAM.

Report of Chemist

To the Director of the Storrs Agricultural Experiment Station:

Sir:—The work of this department during the past year has been to analyze various samples of feeds, cheese, butter, soils, etc.

In addition to the general analytical work required of this department, an experiment was started to determine the relative amount of nutrients in different varieties of ensilage corn both before and after putting in the silo. This work has not been completed because of the inaccessibility of the samples in the silo.

Considerable time has been spent in determining the amount of carbon dioxide in the air of incubators and under sitting hens. A report of this work appears elsewhere.

A start has been made in field experiments to determine the effect of lime on crop production and soil fertility.

Respectfully submitted,

H. D. Edmond.

Report of the Cheese Investigation

To the Director of the Storrs Agricultural Experiment Station:

Sir:—The Cheese Investigation has been continued upon the same lines pursued during the previous years,—(1) the practical problems of the making and handling of the Camembert and Roquefort types of cheese, (2) the chemical problems, and (3) the biological problems involved in such ripening.

CHEESE MAKING

The time of the cheesemaker during the past year has been largely devoted to experiments to determine the relation of the lactic organisms to the ripening of Camembert cheese. The problem of the making and use of lactic starters with pasteurized or sterilized milk and the differing results obtained with cultures of different origin have brought the whole question of the making and use of starters under review, in co-operation with the bacteriological department. It has been found possible to vary the results obtained materially by such changes in the race of lactic organism used. We have found some races of lactic organisms whose activity could be markedly increased by proper handling and that one of these obtained from imported Camembert improves the flavor of the product materially.

The methods developed by our past two years of practical work were brought together by the cheesemaker into bulletin form. Since such publication the work has been continued upon the phases of the making and ripening in which results were incomplete. Data have been secured which will modify the practice considerably to the improvement

of the cheese. He is now seeking to fix upon a standard for newly made cheese which will ensure a more uniform ripened product.

The work upon the cheese of the Roquefort type has so far been held as secondary to the problems of Camembert. Experiments have been made regularly and have yielded many excellent cheeses—so satisfactory as to convince us that a cheese of that type out of cow's milk will eventually be worked out. Although individual cheeses have approximated the ideals sought the experiments have not yet reached the stage when practical directions for making such cheese can be offered.

CHEMISTRY

The chemical work during the past year consisted mainly in the isolation and identification of some of the chemical constitutents of the ripened cheese. This plan was followed in order to throw some light upon the nature of the enzymes concerned in the ripening process. The presence of certain characteristic end products which accompany tryptic digestion showed that the changes which the cheese curd undergoes are similar in many respects to those produced by the pancreatic secretion. Certain dissimilarities, however lead to the belief that the principal ripening agent, the proteolytic enzyme of the mold, is not identical with either pepsin or trypsin. A detailed discussion of these results will be found in a paper which is submitted for publication, entitled "Some Chemical Phases of the Ripening of Camembert Cheese." For a brief outline of the chemical reactions involved in the ripening process, the reader is referred to an article appearing elsewhere in this report. Other work has been carried on in co-operation with the mycologist, regarding the nutrition and metabolism of certain fungi. This work however, is far from completion and cannot be included in our report.

MYCOLOGY

The mycological work has included a continued supervision of the matter of inoculation of the cheese with various types of ripening agent. Several species of Penicillium have

been experimented with but after thorough test of the most promising of these, there seems to be no reason to alter our previous opinion that better results are secured with pure cultures of the Camembert mold than with any substitute upon that type of cheese. Some interesting alterations of flavor by the introduction of another mold indicate that special portions of the trade may be reached by such introduction. This side of the work has not been allowed to interfere with the original problem of first reaching the texture and flavor at present sought by those who regularly deal in the best imported brands of Camembert. These results contribute to the conviction that with the development of the industry, will lead to the recognition of and a demand for, not one but several varieties of cheese all of the Camembert type. Some of these varieties may already be clearly forecasted, by these results. In purely scientific lines, the description and illustration of the species of Penicillium obtainable, have been continued and the results of three years' work are submitted as a paper entitled, "Cultural Descriptions for Species of Penicillium." Parallel with this, studies of the same species are made accumulating for a future paper upon their comparative metabolic activities, under numerous culture conditions.

Respectfully submitted,

CHARLES THOM, *Mycologist*,

ARTHUR W. DOX, *Chemist*,

Assistant Dairymen, Dairy Division,

Bureau of Animal Industry.

STORRS

Agricultural Experiment Station

STORRS, CONN.

BULLETIN NO. 43, OCTOBER, 1906

THE FACILITY OF DIGESTION OF FOODS A FACTOR IN FEEDING

BY C. L. BEACH

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No. 14. The Elm Leaf Beetle.
No. 20. A Study of Dairy Cows.
No. 21. The Ripening of Cream.
No. 23. The Relation of Bovine Tuberculosis to that of Man and its Significance in the Dairy Herd.
No. 25. The Covered Pail a Factor in Sanitary Milk Production.
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THE FACILITY OF DIGESTION OF FOODS A FACTOR IN FEEDING.

BY C. L. BEACH.

INTRODUCTION.

In a review of the work of this Station in the feeding of dairy cattle (Bul. 34) it was observed that a change in the ration involving an increase or decrease in the proportion of grain and roughage (usually accompanied by an increase in protein) was attended by a corresponding increase or decrease in the milk flow. The deduction was not fully warranted, however, from the fact that changes in the ration usually involved several factors, viz., increase or decrease in protein, calories as well as in the proportion of grain and roughage. The facility of digestion as a factor in feeding is discussed at greater length in this bulletin and additional data presented.

SUMMARY.

A (page 6). *Exclusive meal feeding.* On the average for two animals, 6¼ pounds of cornmeal, containing 4.5 pounds of digestible nutrients, were required for maintenance. For the same animals 13.15 pounds of hay, containing 7.1 pounds of digestible nutrients, were required.

One pound of digestible nutrients in corn meal was found equivalent to 1.57 pounds in mixed hay. Or stated in another way, there were required for maintenance 57 per cent. more digestible nutrients when derived from hay than from corn meal.

B (page 15). An increase in the proportion of grain to roughage in a ration for milch cows tends to facilitate digestion, and is followed by increased production.

C (page 19). *Calf meal as a substitute for milk.* For the young animal a satisfactory substitute for milk must be capable of being easily digested and assimilated. Calf meal did not produce as good gains as skim milk.

D (page 22). *The character of the ration for pigs affecting the gains in live weight.* When the ration consisted of skim milk alone, 230 pounds of digestible nutrients were required for 100 pounds gain in live weight; 258 pounds from milk and shorts, and 294 pounds from shorts alone.

General. The value of a feed depends upon its composition, digestibility and ease or facility of digestion. The first two factors are considered in the formulation of rations. The third factor has only recently been recognized, and little definite knowledge in regard to it is at hand. In a general way, it is recognized that milk is more easily digested than meal; concentrates than roughage; early than late cut hay; silage than corn stover; oat than rye straw. A pound of digestible matter, therefore, should be more valuable in the former than in the latter.

A. EXCLUSIVE MEAL FEEDING.

"In 1874, Mr. Linus W. Miller of New York reported that for several years he had successfully maintained a herd of dairy cows, while dry in winter, for a period of about eight weeks, by giving each animal as its sole feed not above three quarts of finely-ground corn meal daily. At first the animals were more or less restless, but they soon quieted down, all rumination ceasing. Only a small quantity of water was drank. The animals remained in fair flesh. In the spring upon changing back to normal feeding, a limited amount of hay was first given and the supply gradually increased. Calves from cows thus maintained were strong and healthy.

A committee was appointed by L. B. Arnold, President of the American Dairymen's Association, to visit Mr. Miller's stable and report its findings. The committee reported that it found that cows weighing about 900 pounds each had been fed on corn meal exclusively for seven weeks, at the time of inspection the animals receiving on the average three quarts of corn meal each, daily. It further reported, "The cows did not ruminate, were very quiet, did not evince any inordinate desire for food when hay was shown them, not so much as cows

that are fed on hay alone, in the usual way of feeding, a little less than they will eat. Were much more quiet than cows fed mostly on meal with a little feeding of hay, say four or five pounds per day. We could not discover any signs of suffering or unrest in any way whatever."

On a second visit of the committee, thirteen days after hay feeding had been resumed in the spring, the cows were "filled up" and did not appear different from others which had been wintered in the usual way. The committee further reported that the calves from the cows "are of more than ordinary size, fleshy, strong, active and healthy."

This system of feeding, or absence of feeding, excited much discussion in the agricultural press at the time, but the practice seems never to have become general and the subject is almost forgotten.*

The point of interest in the above experiment was the small amount of nutrients required to maintain an animal. The Wolff maintenance standard for a 900-pound animal called for .63 pound of protein, 7.2 pounds of carbohydrates and .09 pound of fat. Based upon average digestion coefficients, the three quarts of corn meal (4.5 pounds) would contain .35 pound of protein, 3 pounds of carbohydrates and .19 pound of fat. The maintenance ration for a 900-pound animal calls for 7.93 pounds of digestible nutrients. In the Miller trial the 4.5 pounds of meal contained 3.54 pounds of nutrients, or 50 per cent. less.

Neither from the above comparison or from the experiments that follow does the writer wish to be understood as advocating exclusive meal feeding. These trials are of interest, however, as illustrating a principle or factor in animal nutrition that experimenters have frequently lost sight of, viz., that digestible nutrients in concentrated feeds are more valuable pound for pound than digestible nutrients in roughages, because less energy is required by the animal in the former case to render them available.

*Henry's Feeds and Feeding, p. 94.

NET AVAILABLE ENERGY IN MEAL AND HAY.

On December 12, Mina, a grade Jersey cow, five years old, dry and farrow, was placed on an exclusive hay ration. On the same date Ethel, a grade Jersey cow, five years old, dry and farrow, was placed on an exclusive corn meal ration. Mina weighed 800 pounds and Ethel 730 pounds. Both cows were weighed daily and the ration adjusted to maintain the initial weight. Stable temperatures, temperature and amount of water drank were taken and recorded daily. The cows received no exercise. The feeding trial continued until April 23, or a period of 130 days. The last week of the trial the feces were collected and analyzed.

TABLE I.

Amount of hay versus meal required for maintenance.

Experiment I.

Date.	Temp. of Water in Barn.	Temp. of Barn.	Mina. Average Weight of Animal.	Mina. Water Drank Daily.	Mina. Hay Consumed.	Ethel. Average Weight of Animal.	Ethel. Water Drank.	Ethel. Meal Consumed Daily
	°	°	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs
December 9–12.....	—	—	800	—	—	730	—	—
Dec. 13–Jan. 6......	—	—	—	—	15	—	—	6
January 7–13.......	35	42	792	30.4	14	651	9.2	6
January 14–21......	36	44	800	34.	14	651	10.	6
February 1–7.......	34	40	784	29.	14	675	9.8	6
February 20–26.....	35	43	788	30.	14	675	8.4	6
March 4–13........	36	47	794	29.4	14	675	9.6	6
March 25–April 2...	38	51	791	29.4	15	659	9.8	6
April 10–15........	41	53	805	80.4	15	653	10.7	6
April 17–23........	42	52	795	31.	15	647	6.3	6
Average.........	37	46	793	30.4	14.3	661	9.2	6

TEMPERATURE.

The temperature of barn and drinking water were taken morning and evening of each day, beginning January 14. The temperature of the water drank ranged from 35° January 7-13 to 42° April 17-23. The barn temperature ranged from 42° on January 7-13 to 52° on April 17-23.

FEEDING PERIODS.

From December 12 to January 6 was considered a preliminary period. Previous to this time the cows were fed hay, silage and a small amount of grain. During the preliminary period the roughage in Ethel's ration was reduced at the rate of one pound per day and the meal gradually increased. This change was completed on December 24, and after this Ethel received six pounds of corn meal daily and no other food. Rumination ceased shortly after, but the animal evinced no apparent discomfort.

AMOUNT OF RATION.

In the case of the exclusive hay diet, and the exclusive meal diet as well, the amount of the ration was adjusted as near as possible to maintain the live weight of the animal. During the preliminary period Mina received 15 pounds of mixed hay per day and Ethel 6 pounds of corn meal. During the first 73 days of the experiment Mina received 14 pounds of hay daily and 15 pounds daily in the last 33 days of the trial. Ethel received 6 pounds of corn meal daily, in three feeds, from December 24 to April 23. During a part of the time the meal was consumed with apparent relish. At other times the allowance of meal in whole or in part would remain uneaten from one feeding period to the next. At these times there was an apparent lack of saliva to properly moisten the food for mastication. Several times during the experiment the meal that had become fouled was weighed back and an equal amount of fresh meal placed in the manger. Six pounds of meal, however, was fed daily in the experimental period and the animal consumed 636 pounds in the 106 days.

WATER DRANK AND EXERCISE.

The amount of water drank by the cow on the hay diet was an average of 30.4 pounds per day. The cow on the meal diet drank an average of 9.2 pounds per day. The animals received no exercise except as they were led from the stall to the scales daily to be weighed.

LIVE WEIGHT.

The animals were weighed daily and an attempt was made to adjust the amount of the ration to maintain the initial weight of January 7-13. Mina weighed 792 pounds (average of seven weighings) on January 7-13, and 795 pounds at the close of the trial, April 17-23. Ethel weighed 730 pounds on December 9-12 and 651 pounds on January 7-13. This shrinkage is attributed to a loss of food in the paunch and digestive tract as a result of the change from roughage to a concentrate diet. There is some doubt in the mind of the writer whether all of the material in the paunch, derived from the previous roughage ration, was eliminated even after the 106 days of exclusive meal feeding. In the case of Ethel, after 106 days of exclusive meal feeding, and in a later trial with Mina after 50 days of exclusive meal feeding, more crude fibre was found in a week's composite sample of the feces than could be accounted for in meal consumed for the same period. Ethel weighed 651 pounds on January 7-13 and 647 pounds on April 17-23. The physical condition of the animal at the close of 106 days of exclusive meal feeding was as good, if not better, than at the beginning of the trial. It is possible that by the substitution of fat for water in the body Ethel may have gained in flesh while maintaining a uniform live weight. At the close of the exclusive meal trial Ethel received an exclusive hay diet, and on May 2-8 weighed 794 pounds, which is 19 pounds more than she weighed at the beginning of the exclusive meal feeding on December 9-13.

At the close of the first trial on April 24 the rations for the two animals were reversed. Mina received an exclusive meal ration and Ethel an exclusive hay ration. The change in

ration was completed in a week's time, but the preliminary period was extended to May 20, in order that the animals might have time to adjust themselves to the ration.

Mina received 6 pounds of corn meal daily from May 2 to 20, 7 pounds daily from May 21 to June 3, and 6 pounds daily from June 4 to 19. This latter amount would probably have maintained the weight of the animal, although she weighed 26 pounds more than Ethel. The stable temperature and the temperature of the water drank were higher than in the first trial.

Ethel received an exclusive diet of 12 pounds of hay from May 2 to June 19. Judging from the live weight of the animals, this amount of hay did not seem to quite furnish a maintenance ration. Her physical appearance at the close of the trial pointed in the same direction.

TABLE 2.

Amount of hay versus meal required for maintenance.

Experiment II.

DATE.	Temp. of Water.	Temp. of Barn.	MINA. Average Weight of Animals.	MINA. Average Weight of Water Drank Daily.	MINA. Meal Consumed Daily.	ETHEL. Average Weight of Animal.	ETHEL. Average Weight of Water Drank Daily.	ETHEL. Hay Consumed Daily.
	°	°	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
April 24–May 1......	—	—	—	—	—	—	—	—
May 2–8........	—	—	721	—	6	749	—	12
May 14–20.........	—	—	704	—	6	735	—	12
May 21–27........	55	64	679	11.5	7	735	30.	12
May 28–June 3....	58	66	687	11.3	7	728	29.	12
June 4–10..........	60	68	700	10.	6	728	31.	12
June 13–19..........	62	73	684	11.4	6	722	28.1	12
Average..........	58	68	687	11.0	$6\frac{1}{2}$	728	29.	12

TABLE 3.

Digestion trial with cow fed corn meal, average of one day.

	Dry Matter.	Protein.	Crude Fibre.	Nitrogen Free Extract.	Ether Extract.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Mina, Experiment II.					
6 lbs. corn meal consumed .	5.210	.509	.126	4.304	.203
3.78 lbs. dung............	.801	.162	.166	.356	.051
Digested..............	4.409	.347	—.040	3.948	.152
Per cent. digested.........	84.6	68.1	—	91.7	74.8
Ethel, Experiment I.					
6 lbs. corn meal consumed .	5.081	.503	.123	4.166	.223
3.7 lbs. dung.............	.826	.181	.162	.380	.045
Digested..............	4.255	.322	—.039	3.786	.178
Per cent. digested.........	83.7	64.0	—	90.8	80.0

DIGESTION EXPERIMENT.

During the last week of each feeding period the feces were collected for seven days, weighed, sampled and analyzed. Samples of hay and meal were also analyzed. The results of the digestion trials for the last week of each feeding period are given in Tables 3 and 4. The digestion coefficients thus obtained have been used to calculate the digestible nutrients consumed for the entire period as given in Table 5.

TABLE 4.

Digestion trial with cow fed hay, average of one day.

	Dry Matter	Protein	Crude Fibre.	Nitrogen Free Extract	Ether Extract
Mina, Experiment I.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs
15 lbs. hay	13.596	1.297	4.416	6.526	.504
24.07 lbs. dung	5.213	.608	1.524	2.318	.236
Digested	8.383	.689	2.892	4.208	268
Per cent. digested	61.7	53.1	65.5	64 5	53 1
Ethel, Experiment II.					
12 lbs. hay	10.638	1.057	3.482	5.149	322
18.28 lbs. dung	3.775	.503	.971	1.675	.239
Digested	6.863	.554	2.511	3.474	083
Per cent. digested	64.4	52.4	72.1	67.4	26.

TABLE 5.

Digestible dry matter nutrients in hay and in corn meal required for maintenance.

	Weight of Animal.	Character and Daily Amount of Rations.	Dry Matter.	Protien.	Crude Fibre.	Nitrogen. Free Extract.	Ether Extract.
	Lbs.	Lbs.	Lbs.	Lbs	Lbs.	Lbs.	Lbs.
Mina, I.	800	14.3 hay	7.992	.656	2.757	4.013	255
Ethel, II.	730	12. hay	6.863	.554	2.511	3.474	.083
Average	—	13.15 hay	7.427	.605	2.634	3.743	.164
Ethel I.	800	6 corn meal	4.255	.322	—.039	3.786	.178
Mina, II.	730	6½ corn meal	4.775	.376	—.043	4.275	.164
Average	—	6¼ corn meal	4.515	.349	—.041	4.030	.171

DISCUSSION OF RESULTS.

The reader should bear in mind the limitations in connection with the report of this experiment, namely, the amount of feed reported as consumed daily in Table 5 is the average for the entire feeding periods. The amount of digestible nutrients reported as consumed daily is based upon calculations from digestion coefficients secured during one week only of each feeding period. Admitting that the live weight of each animal was sustained in each trial, it may be questioned whether the animals did not gain or lose in flesh in the same periods by the substitution of fat for water in the carcass or the reverse. The animals on the corn meal diet were more or less irregular in eating, drinking and the passing of dung. The amount of manure passed by Ethel during the week of the digestion trial in the first experiment was more than the average, and the weight of the feces for the week preceding was used in the calculations. The possible error arising from the above conditions could scarcely account, however, for the marked differences in results obtained. On the average for the two animals 13.15 pounds of hay, containing 7.1 pounds of digestible nutrients, were required for maintenance. For the same animals 6¼ pounds of corn meal, containing 4.5 pounds of digestible nutrients, was sufficient. One pound of digestible nutrients in corn meal was found to be equivalent to 1.57 pounds in mixed hay. Or, stated in another way, there were required for maintenance 57 per cent. more digestible nutrients when derived from hay than from corn meal. The explanation of this marked difference lies in the fact that a considerable part of the value of the food eaten is used in the processes which are necessary to prepare the food for the use of the body. First, a certain amount of muscular exertion is required to grasp, chew and swallow the food, and to move it through the alimentary tract. Second, losses occur from an escape of unconsumed gases, due to fermentation that takes place during digestion. Third, more or less energy is used in the convertion of digested material into forms suitable to nourish the cells of the body. "In all these ways more or less of the energy of the food, as

measured by its fuel value (digestible nutrients), is converted into heat, and when once it takes this form it is of use only in so far as it may be needed to keep the body warm, while it cannot be used to replace lost tissues or to build up new. The total expenditure of energy in these processes has been designated as the work of digestion and assimilation."*

Much more energy is required to masticate and digest roughages than concentrates. The loss resulting from fermentations in the digestion tract is also greater with the former class of feeds than with the latter. Zuntz has shown that 11.3 per cent. of the energy of hay and 2.8 per cent. of oats was used in chewing these substances. "The same author calculates that the work of mastication and digestion combined is 48 per cent. of the energy value of the digested material from hay and 19.7 per cent. of that from oats."†

Less digestible nutrients from corn meal, therefore, were required for maintenance than from hay, because less energy of the feed was used in the work of digestion and assimilation. A similar explanation will account for the more rapid gain of the pigs fed skim milk than those fed middlings (page 22); for the more rapid gain of the calves fed skim milk than those fed Blatchford's meal (page 19), and for the greater gain in live weight of the cows fed the most concentrates (page 8).

B. PRODUCTIVE VALUE OF NUTRIENTS IN CONCENTRATES AND ROUGHAGE.

In the preceding experiment it was shown that a considerably less amount of digestible nutrients was required for maintenance when the ration consisted of corn meal than when composed of hay. The extra nutrients required in the roughage ration is attributed to the extra energy required in digestion and assimilation and to the loss of energy resulting from fer-

*Armsby, Penn. Bulletin 71.

†Jordan, The Feeding of Animals, p. 165.

mentations in the digestive tract. These results are of wide application. Digestible nutrients in concentrates are more valuable than in roughages as they furnish more net energy. The marked difference in values applies to production as well as to maintenance.

TABLE 6.

Effect of grain on milk flow.

A. Grain increased more than 1 pound and from below 8.
B. Remainder in which grain was increased.
C. Grain decreased.

Ration.	Number of Cows.	Protein.	Calories.	Grain.	Dry Roughage.	Silage or Roots.	Milk.
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
A							
Original.........	80	1.69	28,160	6.2	14.7	18.4	16 07
Recommended..	80	2.29	27,595	8.2	13.6	9.1	17.13
Difference....	—	+.60	—565	+2.0	—1.1	—9.3	+1.06
B							
Original.........	105	1.92	26,985	9.1	13.9	5.5	17.24
Recommended. .	105	2.42	26,540	9.97	12.2	5.3	17.44
Difference....	—	+.50	—445	+.87	—1.7	—.2	+.20
C							
Original.......	92	1.95	29,575	10.1	15.7	4.3	18.45
Recommended...	92	2.37	27,380	9.25	14.1	4.5	17.95
Difference.....	—	+.42	—2,195	—.85	—1.6	+.2	—.50

A. Grain increased 2 pounds and protein .6 pound, resulting in 1.06 pounds increase in milk flow.

B. Grain increased .87 pound, protein .5 pound, resulting in .2 pound increase in milk flow.

C. Grain decreased .87 pound, protein increased .42 pound, resulting in .5 pound decrease in milk flow.

In a study of 21 herds of 277 cows (Report 1904, p. 166) it was shown that an increase in the concentrates of a ration was attended with an increase of the milk flow, and that a decrease in the concentrates was attended with a decrease in the milk flow. The increase or decrease in the milk flow resulting from a change in the ration followed more closely the increase or decrease of concentrates than the change in the amount of protein or calories.

In the above trials the effect of an increase or decrease of concentrates in the rations was obscured by the accompanying increase in protein and decrease in calories. In the following experiment the amount of protein and calories of the two rations composed are the same, the only varying factor is in the proportion of grain to roughage.

Six cows in the College herd were fed in periods I. and III. a ration containing 6 pounds of grain and in period II. a ration containing 11¼ pounds of grain. Both rations contained the same amount of protein, carbohydrates and fat.

TABLE 7.

Ration fed in periods I. and III.

Kind and Amount of Feed.	Digestible Nutrients.		
	Protein	Carbo-hydrates	Fat.
	Lbs.	Lbs.	Lbs
50 lbs. corn silage	.45	5.65	.35
5 lbs. hay	.15	2.17	.07
1.2 lbs. cotton seed meal	.456	.22	.10
4.8 lbs. bran	.58	1.92	.15
	1.636	9.96	.67

TABLE 8.

Ration fed in period II.

Kind and Amount of Feed.	Digestible Nutrients		
	Protein.	Carbo-hydrates.	Fat
	Lbs	Lbs	Lbs
30 lbs corn silage	.270	3 39	21
5 lbs. corn meal	.395	3.33	215
3 lbs. barley	.261	1.96	033
2 lbs. bran	.244	78	054
1¼ lbs. cotton seed meal	.465	21	15
	1.635	9.67	662

TABLE 9.

Production resulting from two rations containing the same amount of protein and total nutrients.

	Feed Eaten.			Digestible Nutrients.		Products.	
	Silage.	Hay.	Grain.	Protein.	Total.	Milk.	Gain (+) or Loss (—) Live Wt.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Period I	4,200	420	504	137.4	1,030	1,062	+8
Period II	2,520	—	945	137.3	1,005	1,105	+113
Period III	4,200	420	504	137.4	1,030	1,046	—18

In the first and third periods of the above trials, six cows consumed 1,030 pounds of total nutrients, 137 of which was protein. In the second trial the amount of protein and total nutrients was practically the same, but the nutrients were derived more largely from concentrates. Less energy was required to digest the feed eaten in the second period and a larger percentage of the nutrients were available for production. In this case the increased production took the form more largely of increase in live weight, with a slight increase in milk flow. Had the trials taken place in an earlier period of the lactation of the cows, the increase in the milk flow would probably have been greater. This experiment indicates, however, that nutrients in concentrates are more valuable than nutrients in roughages. The value of feed depends not only upon its content of digestible nutrients but also upon the ease of digestion and assimilation.

C. CALF MEAL AS A SUBSTITUTE FOR MILK.

The food requirements for a given gain increases with the age of animals. The steer requires 7.4 pounds of digestible organic matter to produce one pound increase in live weight, while the calf makes the same gain from 1.57 pounds of dry matter.* To secure these economic gains, the ration of the calf must be liberal in amount, easily digested and rich in nutrients suitable for growth.

The calf designed for beef purposes may be pushed for the most rapid gains. The dairy calf should be kept in a thrifty growing condition, but should not be allowed to become fat. "A calf intended for a dairy cow should not gain more than one and one-half pounds per day for the first four months and less thereafter."†

The most rapid gains with calves can be made with mother's

*Jordan's Feeding of Animals, p. 404.
†Henry's Feeds and Feeding, p. 340.

milk. Skim milk reinforced with hay and grain will produce satisfactory gains with calves, especially those designed for dairy animals. Several substitutes for milk have been recommended among which are hay tea and the various calf meals. The gains made from milk by calves at several experiment stations are shown in Table 10 and the gains from milk substitutes in Table 11.

TABLE 10.

Gain by calves fed milk.

	No. of calves.	RATION	Days fed.	Daily gains.
				Lbs.
Kansas Bul. 126	22	Running with dams..........	140	1.77
Kansas Bul. 126	10	Grain, roughage, whole milk...	154	1.86
Kansas Bul. 126	130	Grain, roughage, skim milk....	125	1.58
New Hampshire	8*	Grain, roughage, skim milk....	124	1.35
Storrs, Bul. 28	9†	Grain, roughage, skim milk....	180	1.25
Storrs. Bul. 28	8‡	Roughage, skim milk.........	191	1.31

*Fed 56 lbs. whole milk.
†Fed 90 lbs. whole milk.
‡Fed 220 lbs. whole milk.

TABLE 11.

Gains by calves fed milk substitutes.

	No. of calves.	RATION	Days fed.	Daily gains.
				Lb.
Kansas Bul. 126	10	Mixed hay tea, grain, hay.....	133	.86
Kansas Bul. 126	10	Alfalfa hay tea, grain, hay....	128	.36
Penn. Bul. 60	13	Calf meal, grain, hay.........	112	.80

In the above trials, calves fed whole milk with grain and roughage gained 1.86 pounds per day, and calves nursing their dams gained 1.77 pounds per day. Calves fed skim milk with grain and roughage, in the Kansas trials gained 1.58 pounds per day; New Hampshire 1.35 pounds per day; and Storrs 1.3 pounds per day.

Calves fed mixed hay tea with grain and roughage gained .86 pound per day; with alfalfa hay tea .36 pound; and on calf meal in Pennsylvania's trials .8 pound per day. The gains made by calves fed milk substitutes in the above trials can hardly be considered satisfactory when compared with the gains of calves fed on skim milk.

TABLE 12.

Skim milk compared with calf meal (Storrs).

	No. of calves	Feed Eaten.			Gain in weight.	Estimated dry matter (exclusive of hay and bran) required for 1 pound gain.
		Whole milk.	Skim milk	Calf meal		
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Lot 1, Milk....................	4	764	3412	—	364	1.09
Lot 2, Calf meal................	4	600	424	240	188	1.79

In this trial each lot of calves received equal amounts of hay and bran. Lot 1 receiving skim milk made nearly twice the gains of Lot 2 fed calf meal. Exclusive of the hay and bran fed, the estimated dry matter required for one pound of gain was 1.09 with skim milk and 1.79 with calf meal. Henry* has shown that for pig feeding 475 pounds of skim milk containing 37.9 pounds of digestible nutrients are equivalent to 100 pounds of corn meal containing 78.9 pounds of digestible nu-

*Henry's Feeds and Feeding, p. 572.

trients. This difference in the value of nutrients may be attributed in part to a difference in the ease of digestion and assimilation.

The smaller gains made by Lot 1 is attributed to the inability of the calves to digest and assimilate the calf meals. For the young animal a satisfactory substitute for milk must be capable of being easily digested and assimilated.

D. THE CHARACTER OF THE RATION FOR PIGS AFFECTING THE GAINS IN LIVE WEIGHT.

The pig among farm animals is noted for his great capacity for assimilation. But with this animal the economy of gain is greatly affected by the character of the ration. The data in Table 13 is taken from Bulletin No. 39 of the Storrs Experiment Station.

One lot of three pigs required 2,739 pounds of skim milk containing 230 of digestible nutrients for 100 pounds of gain. Eight lots, of 28 pigs required 1,086 pounds of skim milk and 253 of shorts, containing 258 pounds of digestible nutrients, for 100 pounds of gain. And one lot of three pigs required 445 pounds of shorts containing 294 pounds of digestible nutrients for 100 pounds of gain.

Milk is an easily digested food. When fed alone in the above trials, 100 pounds of gain were made from the least amount (230 pounds) of digestible nutrients. When shorts were substituted for a portion of skim milk, more nutrients (258 pounds) were required for 100 pounds gain in weight. When shorts were fed alone the most nutrients (294 pounds) were required for the same gain.

TABLE 13.

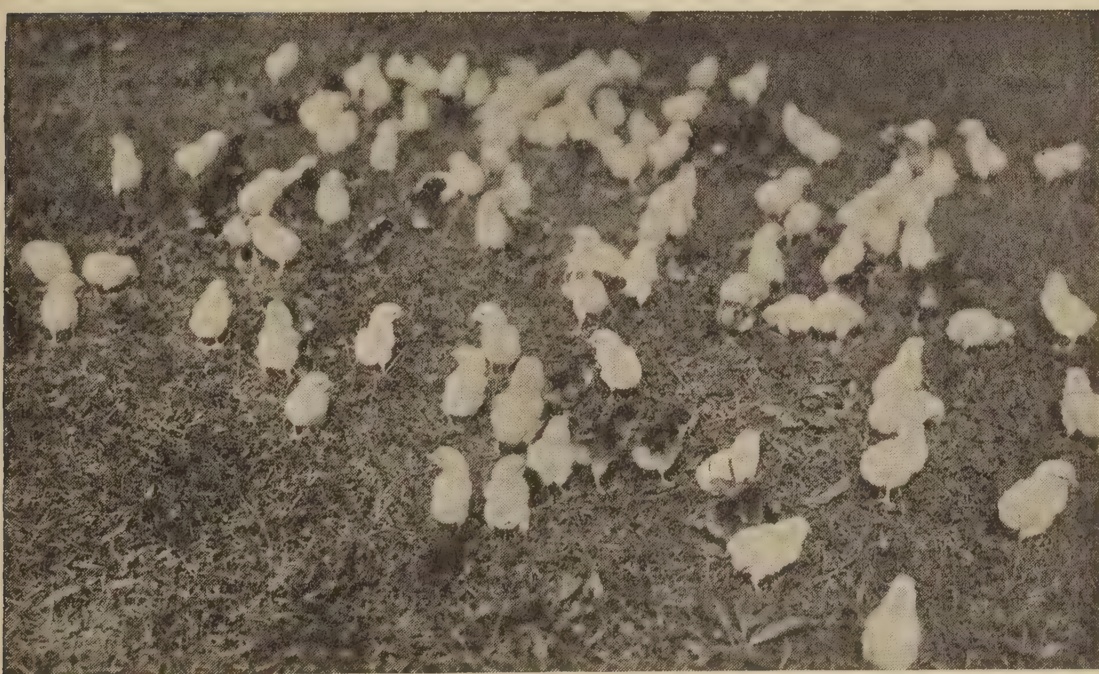
Digestible nutrients for 100 pounds of gain with pigs—milk, milk and shorts, and shorts.

Number of Trials.	Number of Pigs.	Weight at beginning.	Gain per day.	Skim Milk.	Shorts.	Estimated digestible nutrients for 100 lbs. gain.
		Lbs.	Lbs.	Lbs.	Lbs	
1	3	24.3	.72	2,739	—	230
8	28	34.5	1.07	1,086	253	258
1	3	25.3	.47	—	445	294

The reader should bear in mind that the financial problem is not here considered. It is admitted that while skim milk is easily digested, it is too bulky in character. The capacity of the pig to digest and assimilate is greater than its capacity to consume this watery fluid. At ordinary market prices, a pound of digestible nutrients would cost twice as much in skim milk as in shorts. Experience shows that from a financial standpoint, the most economical gains are made when skim milk and grain are fed in the proportion of 3-4 to 1. But the trials show, from a physiological standpoint, that less nutrients are required for a given gain when the ration consists of easily digested foods. These results are in harmony with those reported elsewhere in this bulletin. The conclusion seems warranted that the food requirements for maintenance and for production (milk or growth) depends not only upon the composition and digestibility of a ration but also upon the facility with which it is digested and assimilated.

STORRS
Agricultural Experiment Station,
STORRS, CONN.

BULLETIN No. 44, NOVEMBER, 1906.



POULTRY OBSERVATIONS.

I. Causes of Death of Young Chicks.

II. Substitute of Snow for Water.

BY C. K. GRAHAM.

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No. 14. The Elm Leaf Beetle.
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No. 23. The Relation of Bovine Tuberculosis to that of Man and its Significance in the Dairy Herd.
No. 25. The Covered Pail a Factor in Sanitary Milk Production.
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REPORTS.

The Reports of the Storrs Agricultural Experiment Station for 1889, '90, 94 (Part III.), '95 (Part III.), '96 (Part II.), '98, '99, 1900, 1901, 1902-3, 1904, 1905, are available for free distribution.

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POULTRY OBSERVATIONS.

By C. K. Graham.

CAUSES OF DEATH OF YOUNG CHICKS.

There have been many reports of artificially hatched chicks dying during the first ten days in the brooder. Most of these die from looseness of the bowels, or what is commonly known among poultrymen as white diarrhea.

Different breeders have different theories as to the cause of this trouble, among them being irregular temperature, lack of vitality of breeding stock, improper feeding, and poor ventilation; the latter applying not only to the brooder but also to rooms in which incubators are run.

The Ontario Department of Agriculture appointed a commission a year ago to investigate the cause of this mortality, and they seem to think the last mentioned cause is the primary

Fig. 1.—Sick Chickens.

one (Ontario Agricultural College Report, 1905). This station never had such a case till last spring. In January about 150 chicks were hatched, and no symptoms were seen, but in February about 400 chicks were hatched in different incuba-

tors and from eggs both from the College stock and from stock in different parts of the state, and nearly every chick died. About 500 were hatched in March, and none of these showed any symptoms of the trouble, nor have there been any symptoms since.

The incubator cellar has a chimney hole about three feet from the ceiling that has always been left open for ventilation; but during February last it was necessary to have some heat in the room during the noon hour each day, and an ordinary cook stove was used. This was taken down during the last week in February. During the time the stove was in use there was found to be about eighteen parts of carbonic acid gas in the room, as compared with nine parts a month later (after the stove was taken down).

Another case was noticed where eggs from a neighbor's stock were used. This neighbor has a very warm hen house and has had trouble with roup for several years. The eggs on one side of a tray were White Rocks from the College stock; the neighbor filled the other half of the tray with eggs from Barred Rocks. The chicks were all put in one brooder and only one case of bowel trouble was noticed in the white chicks, while all the neighbor's died. This was caused, no doubt, by lack of vitality in the parent stock.

While a large majority of the deaths are from the causes just mentioned, still, improper food seems to be an important factor.

In order that the effect of different feeds might be ascertained, the chicks from one incubator were divided among four brooders, all of the same construction and in the same building. These flocks were fed different well known chick feeds, and in one pen the mortality was very high (see Table No. 14, p. 33), while in all four pens the average amount of food consumed by each chick was about the same. After a four days' trial the feeds were changed, and the particular brand which was being used in the pen showing a great mortality apparently caused a considerable increase in deaths in the second flock to which it was fed. About the ninth day the feeds were again

changed to other pens, and this time fully 35 per cent. of the food in question was left by the chicks to which it was offered. A careful examination of the feed was then made, and it was found to contain a fairly large percentage of musty grain, especially the corn, which appeared to form the major portion of the food.

Another flock of 80 chicks was divided in a similar way, and to No. 1 Brooder a mixture of pinhead oatmeal, cracked corn, and cracked wheat was fed; to No. 2, the same mixture, to which was added about 25 per cent. (in bulk) of sawdust; to No. 3, the same, with coarse salt used instead of the sawdust; and to No. 4, the same, with granulated sugar in place of the sawdust. In all four cases there was very little difference in the amount of food consumed. The salt and sugar were always selected first, apparently owing to their bright appearance; but as a rule the chicks did not appear to relish them. By the fifth day over 75 per cent. of the chicks in pens 3 and 4 died, while in pen 2 the chicks were very weak and droopy. No. 1 pen lost only one chick. From the sixth day in the brooder, these chicks were all fed on a ration similar to No. 1, but by the ninth day only a few from Nos. 2, 3 and 4 were living, and these died soon after.

A third lot of 110 chicks was then divided, and Nos. 1, 2 and 3 were fed pinhead oatmeal, cracked corn, and cracked wheat, while the fourth had the coarse salt added to its mixture. The results in this case were similar to those in the former test. On the third day in the brooder, pen No. 2 had coarse salt added to their feed, and while they did not eat all the food placed before them, still, they had apparently eaten a fair share of the salt. These chicks began to die within twelve hours, while those fed salt from the first did not die for three or four days. On the sixth day a third lot was offered salt, and in this case only a small portion of it was eaten; but the effects were equally disastrous. On the ninth day the chicks in pen 4 were offered salt, but they carefully avoided it.

A fourth test was made, using the musty chick feed, and in this case it was noticed that chicks eight or nine days old used

considerable discretion in selecting their grains. From that age on, the amount of food refused by the chicks was considerably more than with the younger stock. This forces the conclusion that many of the deaths among young chicks are caused by musty food, although there is no doubt that faulty brooders, chills, over heating, improper ventilation and lack vitality in the parent stock should all receive proper credit for their share.

Chicks that were hatched by hens, also those taken from the incubators and given to the hens, were offered these same mixtures, but it was exceptional to find a chick that took over a grain or two of salt, sugar or sawdust.

FIG. 2.— Types of Colony Houses Used in Snow Experiments.

SUBSTITUTE OF SNOW FOR WATER.

The cost of unnecessary labor is one of the greatest leaks in the poultry industry. Much time is required to carry water to 500 or 1,000 hens, especially if they are in colony houses, and should the poultryman consider it necessary to have the water heated and served twice daily, the labor will be more than doubled. Since the analysis of eggs shows 65 per cent. water and we have reached a time when many consider wet feeds unnecessary, it is natural to think that water for the fowls is an important matter. Nevertheless, cases have been known where a hen had no water for months except that furnished by

the dew, and a reasonable number of eggs was secured.

The results of some experiments to determine the possibility of using snow instead of cold water are given below, also the results when warm water was used.

In five colony houses (three containing Single Comb White Leghorns and two Single Comb Rhode Island Reds) where the birds have been allowed free range, no water has ever been given except what they might be able to find in the brook, etc. When snow was on the ground, they were allowed to eat or walk in it if they desired. The houses used for these birds were made of ⅞-inch boards, with no lining or paper. There was no covering for them but common matched lumber, and, as the accompanying records will show, there is very little difference in the temperature in and out of the houses.

In houses 5 and 6 (see Table No. 15) where Rhode Island Reds, No. 5 being yearling hens that were kept the previous season in a warm house, but were transferred to this houes in September. Those in No. 6 were pullets, which were put in this house early in May, when very small chicks. Both pens were fed wheat screenings, also beef scraps, from hoppers, and the range was over a low marsh, which was frozen solid most of the time. It will be noticed from the accompanying records that the old birds did not furnish as many eggs, nor did they look as well as the younger birds. They seemed to feel the cold more than the others, and two died.

The old hens were apparently affected by the snow, the egg production being smaller on the days when snow was on the ground, and also considerably less when the ground was frozen; that is, on the cold days when water was not accessible. These conditions do not seem to have affected the younger birds, and they show an increase in eggs immediately after each snow storm, gradually dropping back as the snow disappears.

Houses 28, 29 and 30 (in Table No. 15) continued S. C. White Leghorn pullets. The houses were the same as Nos. 5 and 6, but they were located in a sheep pasture, quite a dry piece of land when compared with the location of 5 and 6.

The birds of only one of these pens had started to lay before Dec. 1st. The other two, so far as I can tell, commenced with the first snow, although having free range, it was quite possible for them to lay away; but even with the first snow there were very few eggs. It will be seen that with these pens the cold weather did not affect the egg production, but there was a noticeable increase in the amount of grain eaten during the cold weeks, when comparison is made with the very mild ones. This, however, may have been caused by the birds foraging more during the milder periods. These birds did not appear to mind the cold, and there was not the slightest sign of frosted combs among them, nor were there any colds.

FIG. 3.—Type of House Used by White Leghorns.

A fourth pen (No. 3) of eighteen White Leghorn pullets taken from the same flock of chicks was housed in a building 12 feet square by 6 feet high at the eaves, boarded inside and out, and covered with paper. A small door from the house to the yard was never closed. They were given a scratch feed of corn, barley, and oats in the morning, a warm mash in the evening, and warm water was put in the fountain daily. This flock looked as healthy and contented as those in the cold houses, but the egg record during the cold weather was very poor.

No. 9 house also is supposed to be warm; that is, it is built on the scratching shed plan, and the room in which the birds roost and lay is covered with paroid paper. The scratching shed has no curtain, simply a 2-inch wire front, and the opening between these two rooms was never closed.

There were eighteen houses similar to No. 9, all containing American varieties. They were fed in litter instead of hopper, but were given no moistened mashes, nor did they have free range, but half of them had access to their small yards where they could walk out or eat snow at their pleasure. One-third of both those with access to snow and those confined were given warm water twice daily, another third had cold water put in their fountains early every morning, while the remainder were given snow when it could be secured and cold water the rest of the time. Table No. 16 shows the daily egg yield in per cent. of each of these pens. In Table No. 17 will be seen the temperature of No. 9 house, and that for the eighteen similar houses would be about the same. This house was found much harder to ventilate or dry out; the ceiling was always damp. The temperature was higher during December and January than in Nos. 5, 6, 28, 29, and 30, still over half the males' combs frosted, and there was in some pens a decided drop both in eggs and fertility just after each severe frost.

Early in February the windows were taken out, and cotton cloth was used instead; after that there was no more trouble from moisture. The houses were a little colder, but the birds suffered less from the cold and appeared considerably brighter.

It will be noticed that in pen 14 the egg yield practically stopped every time snow was used, while in pen 12, which were birds of same variety and age but of a different strain, there was a noticeable increase. No. 14 is the only pen that shows a decrease in eggs every time snow was used. It was noticed, however, that in all the other pens when snow was given there was generally an extra amount of feed required, although the increase in eggs more than paid for it.

The fertility of the entire flock was tested daily, and while

there was a larger percentage of infertile eggs the third day after each cold wave, still there was also a much larger percentage of infertile eggs and weak germs from the birds that had the warm water than from the others. There seemed to be very little difference between those that had access to snow and those given cold water, the latter showing a slightly higher percentage of fertility. Some particular strains (one of White Wyandottes in particular) that had a pen in each test showed practically no fertility till early in March, while in most of the pens it was 65 to 80 per cent., and in the case of the birds that were on free range the fertility was above 80 per cent. all winter, and the chicks hatched from these eggs were exceedingly hardy, while chicks from the pens that were confined were not so strong, although there were times when the fertility seemed fully as good.

The eggs from the birds in confinement have steadily increased in fertility as the season advanced, and the chicks have been much stronger. A peculiar thing, however, is that there is no noticeable difference in fertility of the eggs or vitality of the chicks from hens that were confined to the house and from those on limited range; although on fully one-third of the days this winter the weather would permit the latter to roam anywhere about the yards.

Snow was given to young chicks, but the results were disastrous; although chicks that were reared in out-door brooders were let run on the snow crust during bright days when three weeks old or over, and no serious results followed.

The time saved by using snow and dry mashes amounted to nearly half that required in tending the fowls. The difference in egg production between the use of warm and cold water can be seen easily by comparing pens 10, 22, 24 and 26 with pens 13, 19, 23 and 25. All of these pens contain Barred Rocks, and the egg yield averages about the same, though slightly in favor of those getting cold water. While both of these methods gave a shade better egg production than when snow was given, the increase was not enough to pay for the extra labor.

TABLE No. 14.

Brooder No.	Number of Chicks.	Deaths at end of 4th Day in Brooder.	Deaths between 5th and 9th Days.	Deaths between 10th and 21st Days.
No. 1	31	0	2	1
No. 2	31	1	2	**4**
No. 3	30	**17**	9	4
No. 4	30	1	**12**	8

The heavy type shows where musty feed was used.

TABLE No. 15.

Showing daily egg production in percentage of eggs to number of hens in pens for the periods specified.

	S. C. W. Leghorns.				S. C. R. I. Reds.		
	Warm House.	Cold House.	Cold House.	Cold House	Cold House Old Hens.	Cold House Pullets.	Warm House Pullets.
House Number	3	28	29	30	5	6	9
No. of Hens in House	18	29	26	21	18	23	7
Dec. 1 to 9				6	2	7	10
Dec. 10 to 20		3	1	16	11	12	22
Dec. 21 to 31		4	7	16	20	27	30
Jan. 1 to 7	10	7	16	34	36	38	33
Jan. 8 to 11	13	16	16	35	37	47	36
Jan. 12 to 31	13	14	8	41	37	43	43
Feb. 1 to 8		35	36	48	30	56	46
Feb. 9 to 20	8	31	49	48	31	56	43
Feb. 21 to 28	17	17	54	50	35	60	61
Mar. 1 to 3	36	39	50	45	41	80	53
Mar. 4 to 14	31	52	54	52	51	62	58
Mar. 15 to 27	38	42	47	59	49	68	75
Mar. 28 to 31	28	61	56	59	54	57	36
Average daily yield	13	23	27	38	31	46	43

The birds in No. 9 are sisters to those in No. 6.

These records were taken daily, but to condense matters they have been divided into periods.

Table No. 16.

Daily egg production in percentage of eggs, to hens in pens, for the periods specified.

	See Foot Note.	Pen Number.	Number of Hens in Pens.	Dec. 1 to 9.	Dec. 10 to 20.	Dec. 21 to 31.	Jan. 1 to 7	Jan 8 to 11.	Jan. 12 to 31.	Feb. 1 to 8.	Feb. 9 to 20.	Feb. 21 to 28.	Mar. 1 to 3.	Mar. 4 to 14.	Mar. 15 to 27.	Mar. 28 to 31.	Average Daily Yield.
Buff Orpingtons	S	8	9	**7**	**27**	38	38	**42**	27	40	**39**	37	41	36	**53**	53	35
Barred Rocks	W	10	8				2		11	23	30	38	46	46	42	54	21
White Wyandottes	S	11	12	1	**11**	13	3	**5**	3	5	**11**	22	25	38	**56**	59	19
White Rocks	S	12	8			4	9	**13**	16	26	**39**	54	67	63	**91**	80	33
Barred Rocks	C	13	8	3	17	31	34	25	25	14	20	49	50	65	71	71	36
White Rocks	S	14	15	4		2	2		5	10	**5**	31	29	43	**27**	49	14
Buff Wyandottes	C	15	10	6	7	7	9	10	15	17	20	37	30	62	72	45	27
White Wyandottes	W	16	11	4	5	6	19	21	18	30	28	38	46	71	68	66	31
Lt. Brahma (Late Pullets)	C	17	6		5	11	2		1	1	2	2		9	7	9	4
R. C. Reds	W	18	17		19	28	26	24	14	28	36	43	53	59	61	56	32
Barred Rocks	S	19	16	2	**8**	7	16	**19**	23	23	**31**	13	19	29	**47**	50	23
White Wyandottes	C	20	16	2	2	3	5	10	8	12	10	21	27	34	57	46	18
Black Langshans	S	21	6		**5**	6	5	**13**	13	10	**37**	27	17	38	**50**	38	21
Barred Rocks	W	22	12	4	18	7	22	36	32	30	29	46	45	51	65	60	32
Barred Rocks	C	23	12	15	18	31	38	42	35	25	16	27	28	44	59	34	33
Barred Rocks	W	24	12	2	12	15	18	21	23	14	12	16	20	37	38	40	21
Barred Rocks	C	25	12	3	14	22	19	25	19	25	28	37	34	43	57	40	28
Barred Rocks	W	26	12	3	11	23	22	23	19	40	37	32	39	42	57	32	28

Records were taken daily, but to condense matters were divided into periods.

(s) These pens were given snow during periods marked with heavy type, and cold water the other periods.

(w) These pens were given warm water twice daily.

(c) These pens had cold water daily.

TABLE NO. 17.

Table showing temperature as reported by Weather Bureau at the College, also the maximum and minimum in the different styles of houses for periods recorded in the previous tables.

There were no records kept of the temperature in the houses till January 1st.

	Out Doors.		No. 5.		No. 9.		No. 30.		Weather Conditions.
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	
Dec. 1 to 9...	58	9							Cold.
Dec. 10 to 20.	46	5							Snow.
Dec. 21 to 31.	55	17							Damp.
Jan. 1 to 7....	53	19	60	27	63	28	60	25	Warm.
Jan. 8 to 11...	33	0	39	4	40	5	38	2	Snow.
Jan 12 to 31..	68	13	72	16	74	18	72	13	Damp with light snow flurries.
Feb. 1 to 8...	40	—2	47	4	48	3	48	0	Cold.
Feb. 9 to 20...	41	5	58	8	56	7	58	6	Snow.
Feb. 21 to 28.	51	18	62	20	60	20	62	19	Warm.
Mar. 1 to 3...	34	5	54	8	44	8	54	8	Very cold.
Mar. 4 to 14..	46	15	62	18	56	18	64	12	Rainy.
Mar. 15 to 27.	34	2	58	4	54	4	66	4	Snow and cold.
Mar. 28 to 31.	51	24	59	28	57	27	61	27	Warm

STORRS

Agricultural Experiment Station,

STORRS, CONN.

BULLETIN NO. 45, DECEMBER, 1906.

THE APPLE LEAF-MINER,

A NEW PEST OF THE APPLE.

BY C. D. JARVIS.

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No. 45 The Apple Leaf Miner.

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THE APPLE LEAF-MINER.

A NEW PEST TO THE APPLE.

BY C. D. JARVIS.

SUMMARY.

A small insect known as the Apple Leaf-Miner appeared in unusually large numbers during the past season. Although the insect has been known for about half a century and has become well distributed over the eastern part of the United States and Canada, it has never been regarded as a serious pest until last year, when it was reported as doing serious injury in Vermont.

This year many partially defoliated trees have been observed as a result of this pest.

The insect makes a mine in the leaf, which appears on the upper surface as a large, brownish patch. If many mines occur on the leaf, it will roll up and its functions cease.

Two broods occur in a season. The second is the more serious. The insect spends the winter as a caterpillar within the mine.

Certain parasites are doing efficient work in controlling this pest. Unfavorable weather conditions also contribute to its destruction.

As the insect feeds internally, it cannot be reached by insecticides. The only means at our disposal is to gather up and destroy the infested leaves, or plow them under. The latter operation is recommended for the reason that many other injurious species would be destroyed at the same time.

APPLE LEAF-MINER.*

(*Tischeria malifoliella* Clemens.)

ORDER, LEPIDOPTERA; FAMILY, TINEIDAE.

Many fruit-growers have observed small, brownish patches on the leaves of apple trees. These patches are caused by a minute insect which feeds on the internal tissue of the leaf. The insect has not been regarded as a serious pest, but during the past season it has occurred in sufficient numbers in many sections of New England to cause apprehension on the part of fruit-growers. Our attention was first called to it during the month of July, when the foliage of several trees of the College orchard were observed to be peculiarly affected. At first the injury was thought to be due to spraying, but closer examination revealed the true cause of the trouble.

Later in the season several inquiries, especially from the northern part of the state, were received in regard to an "unknown apple-tree pest," which proved to be the Leaf Miner.

As the outbreak appeared to be of sufficient extent to cause serious loss to the fruit-growing interests of the state, and as the insect is likely to become a well established pest of the apple orchard, we decided to make a study of its life-history with a view of discovering some vulnerable period in its existence. As a result of these observations we believe that we are able to present a more accurate description of the insect in its various stages than has previously appeared. At this time, however, we are unable to give any further information in regard to the methods of controlling the insect. This bulletin, therefore, is for the purpose of calling the attention of the apple-growers to this new pest and to give them the best known method of keeping it in check.

***The Trumpet Miner of the Apple,* Brunn, Second Report (1883), Cornell Agr. Exp. Sta., p. 155. *The Apple Tischeria,* 15th Rept. State Ent. Ill., p. 45 (1889).

HISTORY, NAME AND DISTRIBUTION.

This is apparently an American species. It was first described, in 1860, by Dr. Blackenridge Clemens[1], who proposed its name, *Tischeria malifoliella.* Since that time it has received frequent mention in entomological literature, but has not been reported as doing serious damage. In 1871 Chambers[2] found it in the neighborhood of Covington, Ky. In 1873 its occurrence was reported in Germany[3]. In 1882 and 1883 it was reported in New York state by Lintner[4] and Brunn[5]. Weed[6] found it abundantly in Illinois in 1869. Walsingham[7] reported it in Texas in 1890; Lugger[8] in Minnesota, 1898; Petit[9] in Michigan, 1899; Smith[10] in New Jersey, 1899; Fletcher[11] in Ontario, 1903; Stewart[12] in Vermont, 1905. Excepting one account of its appearance in Texas and one in Minnesota, it has not been reported west of the Mississippi, and has apparently been most prevalent in New England, New York and Ontaria.

WHY SO MANY NEW INSECTS.

With the advent of every new pest comes the question. Why are there more insects now than formerly? Our parents and grandparents grew fine apples, and they gave no attention to insects and the troubles attendant on their treatment. A par-

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[1]Proc. Acad. Nat. Sci. 1860, p. 208.
[2]Can. Ent. III, 208 (1871).
[3]Frey-Boll, Stett. Ent. Zeit., XXXIV, p. 222 (1873).
[4]Rept. N. Y. State Ent., 1882, p. 330.
[5]Rept. Cornell Univ. Exp. Sta., 1883, p. 155.
[6]Rept. Ill. State Ent. 1889, p. 45.
[7]Insect Life II, p. 326 (1890).
[8]Minn, Exp. Sta. Pul. 61 (1898).
[9]Mich. Exp. Sta. Bul. 180, p. 151 (1899).
[10]Rept. Ins. N. J., 1899, p. 482.
[11]Rept. Entomologist Can. Exp. Farm, 1903, p. 193.
[12]Rept. Vt. Exp. Sta., 1905, p. 313.

tial explanation of this fact is found in the many disturbances of nature, chief among which is the removing of our forests, which has forced insects to change their diet. It is true that many species have been imported and others have been more thoroughly distributed. We now have a much better knowledge of insects and consequently they come more frequently under our observation. The question is also largely one of ideals. Our ancestors were satisfied with smaller yields and lower quality; that is, they did not seek for that perfection with which our modern growers are so much concerned.

NATURAL ENEMIES.

The great controlling factor in the insect world is the presence of certain species of insects that prey upon others of their kind. It is probable that climatic conditions have their influence, but the fact that the Apple Leaf-Miner has not before appeared in injurious numbers we believe to be largely due to the efficient work of certain insect parasites. Brunn found two species of Chalcid flies (*Sympiezus lithocolletidis* Howard and *Astichus tischeria* Howard) preying on this insect. Two other species, which were identified by Dr. Ashmead as *Closterocerus tricinctus* Ashm. and *Systomspiesis nigrifemorata* Ashm. were found in vast numbers during the past season busily engaged in depositing eggs on the surface of the mines. Later in the season the pupae of these flies were found to have appropriated the comfortable quarters of the miners which had been killed (Fig. 4).

FIG. 4—Two pupa of parasitic flies beside their dead victim (About twice natural size).

FOOD PLANTS.

While the insect is partial to the apple, we have found its mines on Blackberry and Haw (Crataegus). Chambers states that he "bred it from different species of Haw (Crataegus), Sweet scented crab (Pyrus coronaria), Blackberry (Rubus villosus) and Raspberry (Rubus occidentalis)."

THE INSECT'S WORK.

When once familiar with the work of this insect, it is an easy matter to recognize its presence. Yellowish or brownish blotches are observed on the upper surface of the leaf (Figs. 10, 12 and 17). Mr. Brunn has so accurately described the mine that we cannot do better than to quote him. "The mine, commencing in a glistening spot where the egg was laid, continues for a short distance as a narrow line, gradually growing wider, and then suddenly broadening into an irregular expanded portion or "body of the mine," the whole having a trumpet-shaped appearance. The color of the mine on the upper surface is usually some shade of brown, although I have sometimes observed it to be dirty white. From the under surface of the leaf the mine would hardly be observed unless held up towards the light or examined closely, when the mined portion of the leaf would be seen to be of a lighter shade of green than the rest. The linear portion of the mine on the upper surface is crossed by crescent-shaped patches of white, which in many cases are continued for a short distance into the body of the mine. Often the miner after commencing the body of the mine will turn and eat around the linear portion, obliterating that part and causing the mine to appear like a blotch mine. In such cases the white, crescent-shaped patches will be found somewhere in the body of the mine, indicating the position of the linear portion. These white markings are, however, wanting in some instances; but as the color of the linear portion of the mine is a little darker brown than the rest, we can still tell where the mine commenced."

The mines are sometimes so numerous that as they increase in size they run together and form one large blotch covering the greater part of the leaf (Fig. 5). From such a leaf were taken 68 full grown larvae (Fig. 6), indicating that originally there were as many distinct mines. As the epidermis of the upper surface of the leaf dies it loses its elasticity, and a curling of the leaf inward is the result (Figs. 7 and 8). The leaves at this stage cease to perform their functions and soon drop. The higher branches of the tree are usually more seriously affected and lose their foliage first (Fig. 9 and frontispiece). This loss of foliage results in premature, undersized fruit. By checking its vegetative activity the vitality of the tree will also be more or less reduced. With regard to the extent of injury in Vermont, Professor Stuart has to say: "The injury to the infested trees in the Station orchard was quite

FIG. 5—A very badly infested leaf. The mines have "run together" forming one large blotch covering the greater part of the leaf (slightly reduced).

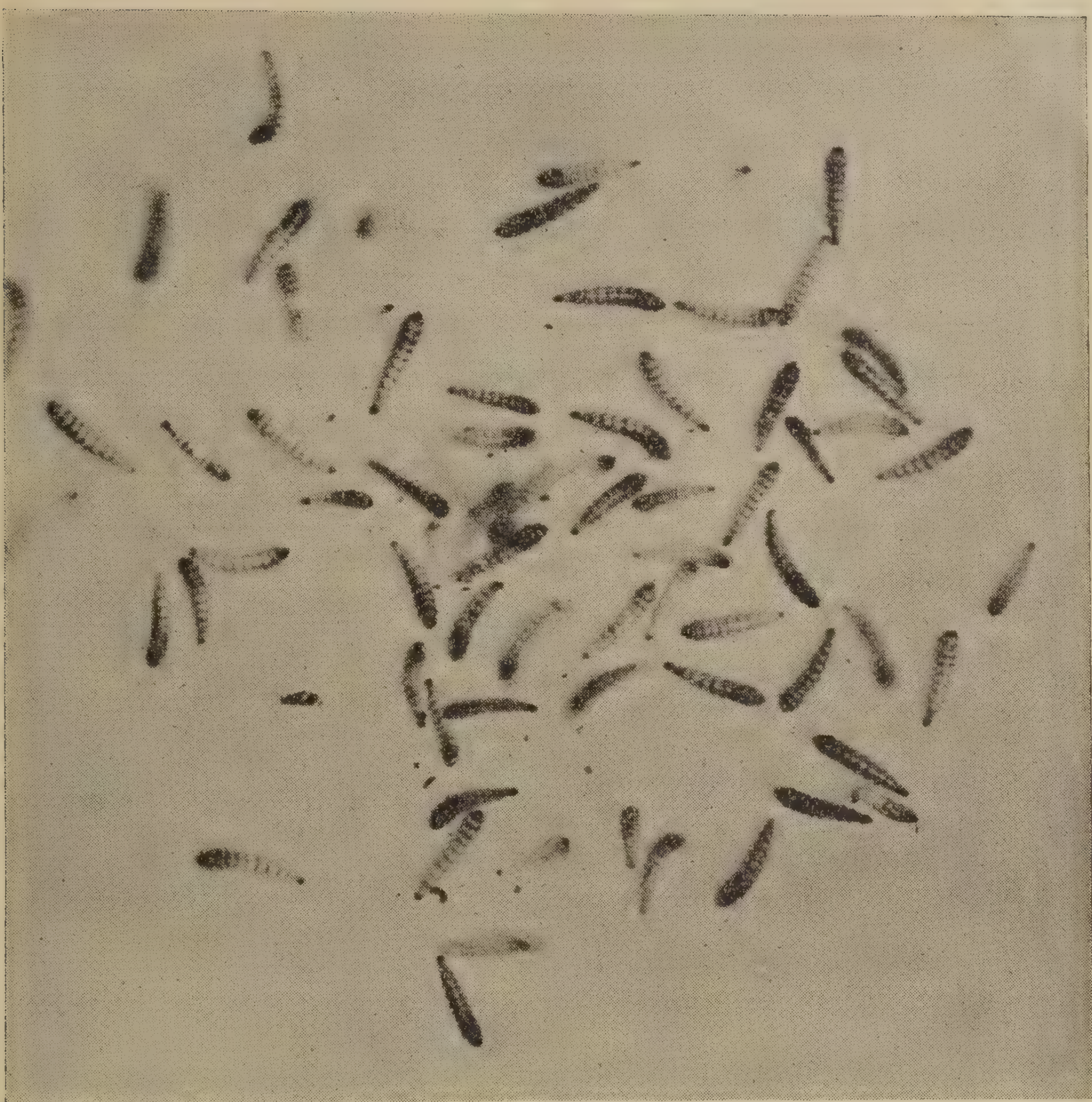

FIG. 6—Sixty-eight full grown larvae taken from the leaf shown in fig. 5 (twice natural size).

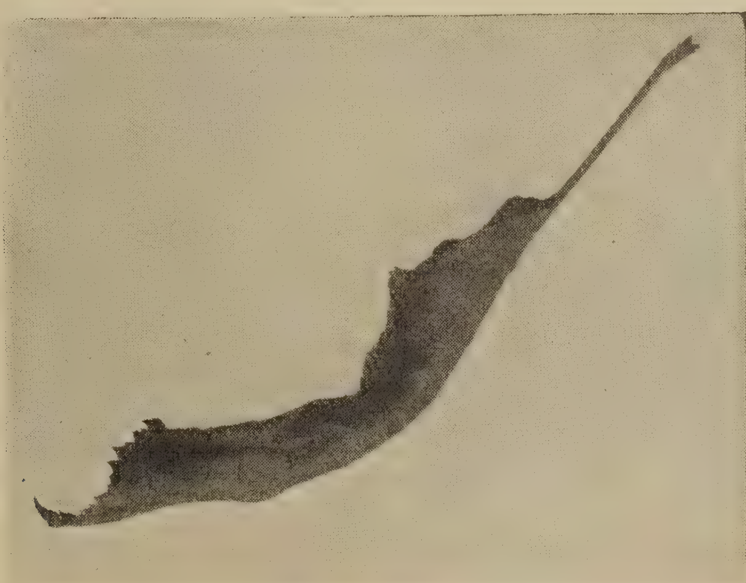

FIG. 7—A curled leaf. Caused by the presence of several mines (reduced).

marked. It was evidenced by the unhealthy appearance of the foliage, its premature loss—the leaves falling from two to three weeks earlier than they normally should—and by the lack of development of the fruit, both in size and quality." Many trees in this locality were so seriously affected that it would be impossible to find on them a single unaffected leaf. There are few apple orchards in the state where the insect cannot be found in sufficient numbers to cause a serious infestation in the future.

LIFE HISTORY AND HABITS.

The main facts and many interesting details of the insect's life and habits were worked out by Brunn in 1883. During the past season, however, we have studied the pest both in the orchard and laboratory, and can now add some important details.

Early in June the tiny eggs are deposited singly on the surface of the leaf, adjacent to one of the larger veins. Each egg is protected by a drop of wax, which appears in the sun-

FIG. 8—A badly infested twig, showing the curling of the leaves.

light as a glistening spot. The eggs hatch in about six days, and the young caterpillars, without exposing themselves to the outside world, immediately enter the leaf. At first they make a narrow channel, but with the increase in size of the insect and its appetite the channel becomes wider, and a trumpet-shaped mine, as previously described, is the result.

The caterpillars moult, or change their coat, five times. These coats are alike in color and structure, but vary in size to accommodate the growing insects. As the old clothes are shed they are judiciously pushed out through a small opening in the lower surface of the mine. The insects further display their cleanly habits, unlike many other leaf-miners, by depositing their excrement without the mine through this same opening.

The caterpillars reach their full growth about the middle of July, when they transform to pupae. This resting stage lasts only from eight to ten days. At the expiration of this

FIG. 9—A badly infested tree. The upper branches have lost their foliage, and the fruit is not fully developed.

FIG. 10—Apple leaf with eight mines. The lighter-colored one on the left is of the first brood. The pupal skin may be seen projecting through a slit in the upper surface of the mine, where it was left when the adult moth emerged. The other, or darker colored mines are of the second brood and contain the caterpillars (reduced).

time the pupae push themselves partly through the upper surface of the mine, break through their pupal skins and appear as fully developed moths, leaving the pupal skins partly projecting through the slit in the leaf (Fig. 10). These tiny moths are very inconspicuous, but on close observation may be seen resting on the apple leaves. Like some other members of this family of insects, the moths assume a peculiar attitude while at rest. The fore legs are extended, while the others

are partly folded under the body. In this way the insect rests on the fore legs and the end of the abdomen.

The female moths, soon after emerging, get the egg-laying habit. The production of eggs seems to be their sole object in life, for after continuing the operation for two or three days, without awaiting the result they die. It is not known just how many eggs are produced by the moths, but we have observed a single moth deposit as many as thirty-eight. It is probable that they are capable of producing twice this number. It is difficult to follow them during the operation, for the same moth seldom deposits more than five or six eggs on the same leaf.

The eggs soon hatch and produce the second brood of caterpillars, which possess similar habits to those of the first brood. They grow more slowly than those of the first brood, not reaching maturity until about September 1st, or possibly later. About this time they cease eating and proceed to make their quarters comfortable for the winter. Unlike the mines of the spring brood, those of the second brood are densely lined with fine white silk. In these comfortable quarters the larvae spend

FIG. 11—Unspotted Tentiform Mine in an apple leaf (slightly enlarged).

the winter. Some writers on the subject hold that they spend the winter in the pupa state, but, in this section at least, that is not the case. In the spring they transform to pupae, and, judging from the time the first mines were observed, the adults appear some time in May.

With one exception the writers on the subject have recorded but one brood in a season. It is certain that a second brood occurs and it is possible that a third brood sometimes occurs. The immature caterpillars which Lintner* observed "toward the last of September" were possibly of the third brood.

OTHER APPLE LEAF MINERS.

Several species of insects are occasionally found mining in apple leaves. Besides the Trumpet Miner, two other species were quite abundant during the past season. One of these

FIG. 12—A serpentine mine on the right and a trumpet mine on the left (slightly magnified).

*11th Rept. Ins. N. Y., 1895, p. 161.

is known as the Unspotted Tentiform Miner of the Apple (*Ornix prunivorella* Chambers). The mines of this species (Fig. 11) are readily distinguished from the trumpet mines by the skeletonized appearance of the upper surface. The other species is known as the Serpentine Miner of the Apple (Fig. 12).

The Ribbed Cocoon-maker of the Apple (*Bucculatrix pomifoliella* Clemens), the Palmer Worm (*Ypsolophus pometellus* Harris) and the Case Bearers are near relatives of the Apple Leaf-Miner.

DESCRIPTION OF THE INSECT.

The Egg (Fig. 13).—Apparently no one up to this time has seen the egg of the Apple Leaf-Miner. It is so small that it cannot be seen with the naked eye. It is not more than one-tenth of a millimeter in diameter; in other words, it would take 250 placed side by side to reach an inch. It is white,

FIG. 13—The egg (greatly enlarged).

translucent, elliptical in outline, and somewhat flattened. A drop of transparent wax, about twice the size of the egg, seals it to the leaf.

The Larva (Fig. 14).—A modification of Brunn's description of the larva follows: Length 5 mm. (3-16 inch). Form

flattened and tapering from the third to the last abdominal segment. Head small, pointed, retractile and bi-lobed. Rudimentary antennae. First thoracic segment twice as wide as head, but only about half as wide as the second and third thoracic segments. Large folds between the first and second and second and third thoracic segments indicate that they are retractile. The last four abdominal segments are much rounder and narrower than the others. There are no true legs, but four pair of inconspicuous prolegs and a pair of anal legs are present. There are three hairs on each side of each thoracic segment, and two on each side of each abdominal segment except the last, which has five. Arising from the same point on each side of the dorsal surface of the third, fourth, fifth and sixth abdominal segments are two short bristles. General color light green, with brown head.

The Pupa (Fig. 15).—Mr. Brunn failed to find the pupa of

FIG. 14—Larva, ventral view.

this insect, but a single specimen was found by Prof. C. M Weed and described as follows:

"Length 4.5 mm.; width 1.2 mm. Antennal sheaths extending nearly to posterior end of third segment from last. Gen-

eral color yellowish brown. A quadrangular space on dorsum of all segments from the first thoracic to the third from the last abdominal, inclusive, has a darker brown ground color, the general appearance of which is rendered still darker by the short, stout, sharp-pointed tubercles with which the surface is studded; color of dorsum of head and thorax slightly darker than ventrum. Body sparsely furnished with moderately long, somewhat spinose hairs. On each side of front of head, which forms a blunt projection, arises a sharp, curved, horn-like process, projecting forward and outward, which when viewed from the side is seen to be bidentate. Tip of last abdominal segment flattened, and furnished at edges with a row of short tubercles curving slightly forward."

Our observations of the pupa agree with this, except that the

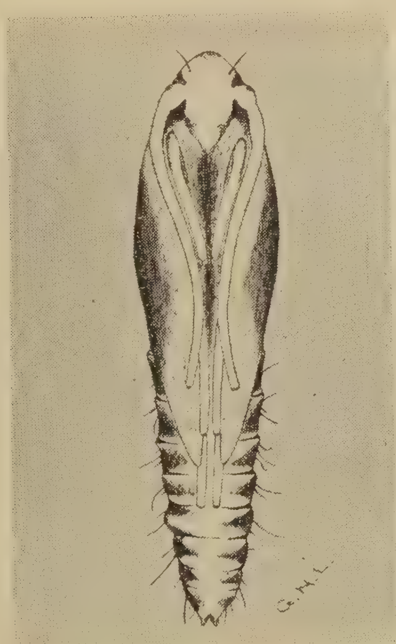

FIG. 15—Pupa, ventral aspect.

antennal sheaths on the specimens examined did not reach beyond the third abdominal segment. The general color we should describe as dark brown instead of "light yellowish brown."

The Adult, or Moth (Fig. 16).—"Head and antennae shining dark brown, face ochreous. Forewings uniform, shining dark brown with a purplish tinge, slightly dusted with pale

ochreous; cilia of the general hue. Hind wings dark gray; cilia with rufous tinge."—Clemens.

The moth measures about 3 mm. in length and about 8 mm. across its expanded wings.

REMEDIES.

In view of the fact that the insect feeds entirely on the inner tissues of the leaf, the application of arsenicals or contact insecticides is useless for the control of this pest. Last season's observations are conclusive that tilled orchards suffered much less from the attacks of this insect than those in sod. The most serious infestation observed during the season was on trees situated on a lawn where the leaves are allowed to remain where they fall. This circumstance is easily understood when we consider the insect's life history—that it spends the winter and early spring within the leaf. With the early spring plowing they are turned under and are unable to return to the surface. The gathering up and destroying of the leaves in the

FIG. 16—Adult with expanded wings.

fall readily suggests itself, and is recommended where tillage is not practiced. There are, however, so many insects of various species which spend part of their existence in the ground and which are destroyed by breaking up their quarters, that, aside from the generally recognized benefits, orchard tillage is, in most cases, recommended.

The various writers are optimistic concerning this insect. Professor Weed says: "I doubt whether the injuries of this insect in the orchard are ever sufficiently serious to repay the labor required for the application of the only remedy for the pest now known—that of gathering and burning the fallen leaves—although I believe this operation would pay in the nursery, where the leaves can be easily gathered, and several injurious species would be destroyed at the same time." Referring to all the leaf-mining species of the apple, Felt* says: "All of these species appear on the foliage so late in the season that comparatively little injury is caused and, as a rule, no remedial measures are necessary." Brunn writes, "This insect is the most abundant of the Tineidae infesting the apple trees at Ithaca, nevertheless it is not abundant enough to do any material injury."

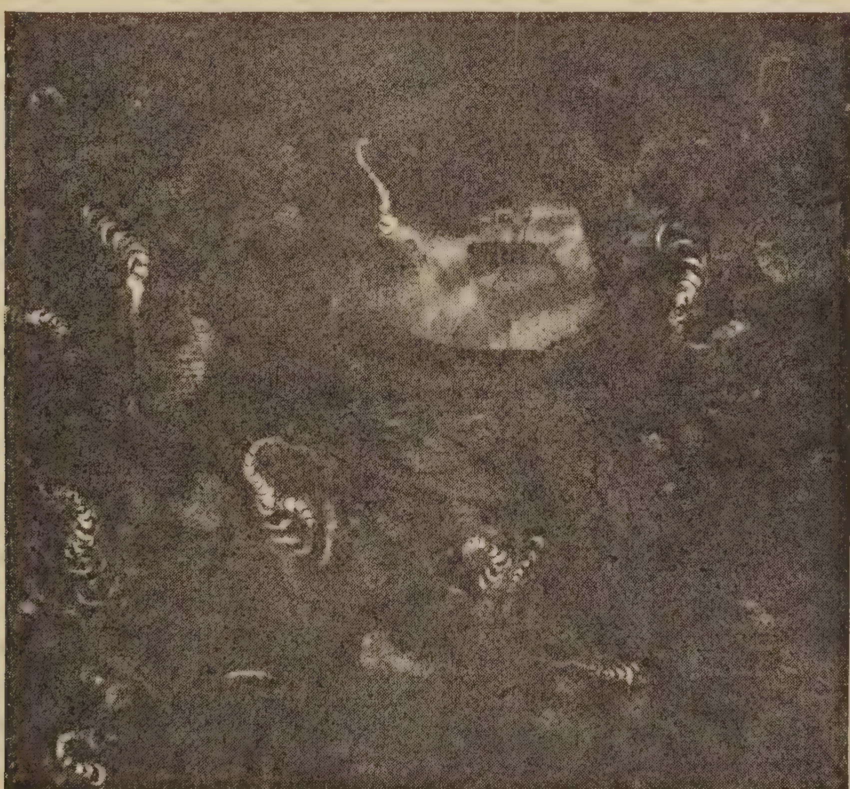

FIG. 17—A mine broken open, exposing the larva. The linear portions of several other mines are very prominent. The body of the mines do not show as distinctly (slightly enlarged).

*N. Y. State Mus. Bul. 97, p. 405, 1905.

It is possible that with the influence of insect parasites and unfavorable weather conditions this insect will never become a serious pest, but if it re-occurs in such numbers as during the past season, it must be reckoned with by the orchardist.

As the insect has been found on the Haw, or Thorn Apple, care should be exercised in preventing the growth of these trees in the neighborhood of the orchard.

HOW DISTRIBUTED.

From the fact that certain sections of an orchard may be seriously infested while in other sections the work of the insect is scarcely visible, we believe that the tiny moths do not fly long distances. The blowing of the leaves by the wind, however, will tend to distribute the insect throughout an orchard or even from one orchard to another.

Fresh infestations are undoubtedly brought about by nursery stock. Messrs. Frey and Boll found the insect in Germany mining the leaves of apple trees imported from America. It would therefore seem advisable to destroy any leaves which may be found attached to the trees or in the packages when purchasing stock from a nursery.

ACKNOWLEDGEMENT.

The writer is indebted to Mr. G. H. Lamson, Instructor in Entomology, Geology and Ornithology, Connecticut Agricultural College, for many valuable suggestions and for the drawings which appear in this bulletin (Figs. 13, 14, 15 and 16).

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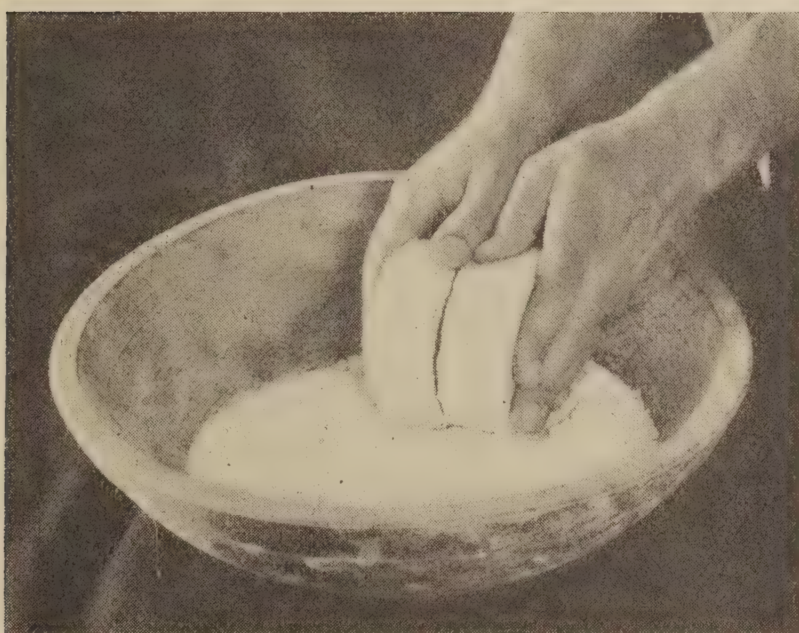

Salting the cheese

DIRECTIONS FOR MAKING THE CAMEMBERT TYPE OF CHEESE

BY THEODORE ISSAJEFF.

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DIRECTIONS FOR MAKING THE CAMEMBERT TYPE OF CHEESE.

INTRODUCTION.

For the past three years co-operative experiments have been conducted between the Storrs Agricultural Experiment Station and the Dairy Division of the Bureau of Animal Industry United States Department of Agriculture for the purpose of determining the methods of making and ripening cheese of the Camembert type. This is one of the varieties of European soft cheese imported in considerable quantities and considered by many a great delicacy. There is a growing demand for cheese of this type in the United States and there is no reason why the industry of making this cheese should not be developed in this country.

The directions given in this bulletin are not compilations, but are founded upon research work covering a period of more than three years. We are now prepared to assist factories and individuals in making this type of cheese. The Connecticut Agricultural College offers a course in cheese making during the winter term, this instruction being given by the experts of the United States Department of Agriculture located at Storrs. Instruction in bacteriology if desired will be provided by the College.

L. A. Clinton,
Director.

CHEESE-MAKING PLANT.

The first problem to be considered is the construction of a suitable plant in which the cheese is to be made and ripened. The description which is here given is not of the plant in which our experiments have been carried out, but is rather of one which is designed to meet certain requirements discussed later, and which our experience has taught us would be most satisfactory.

The plant suggested consists of three rooms, the first of which is used for the making of the cheese, the second for growing the molds and for the first stage of ripening, and the third for the subsequent and final ripening. The size of these rooms depends chiefly upon the quantity of milk which is to be handled.

Note.—All photographs for illustrating this bulletin were made by Mr. C. D. Jarvis, Asst. Horticulturist of Station.

EQUIPMENT OF MAKING-ROOM.

Vats. For the making of Camembert cheese an ordinary flat-bottomed cheese vat is just as satisfactory as the basins used in France.

Marshall rennet tester. A Marshall rennet tester is useful in testing the ripeness of the milk. A more convenient and accurate apparatus, however, is one for determining the percentage of acidity and consists of a burette connected to a large bottle of a tenth normal solution of caustic soda (n-10 Na O H) by a syphon (Fig. 18).

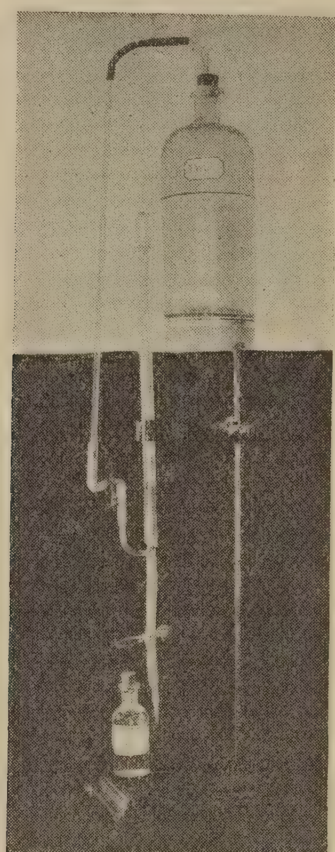

FIG. 18.—Marshall rennet tester.

Curd knife and dipper. A curd knife of the ordinary type must be provided in case the curd is to be cut, and also a dipper, similar in shape to a soup ladle (Fig. 19).

Draining table. The draining table, one end of which is a little higher than the other, is placed near the vat. The top of this table slopes somewhat from both sides toward the center. It is best to have the table on wheels, so that it will be moveable.

Hoops or Forms. The hoops in which the cheeses are made are cylindrical in shape and open at both ends. They are made of galvanized iron, are 5 inches in height and 4 inches in diameter, and are provided with 3 rows of holes about one inch apart. The size of the holes is about ⅛ inch, and there are 13 holes in a row.

A second set of hoops, 2 inches in height with one row of holes around the center, is made with a slightly larger diameter. ⅛ inch is sufficient for these hoops to slide freely over the others (Fig. 20).

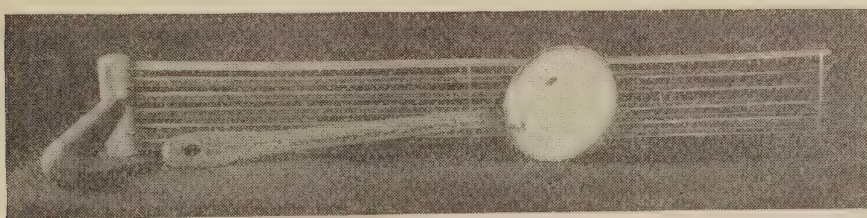

FIG. 19—Curd knife and dipper.

Boards. The draining boards are made of white wood and have parallel grooves on both sides to enable the whey to run off readily. These grooves are about 1-16 inch wide and of the same depth, and are about ⅛ inch apart. The boards are about 15 x 15 inches square or large enough to hold nine cheeses of common size (Fig. 21).

Mats. Square mats of the same size are needed to cover these boards. They are preferably made of fine bamboo strips, closely fastened together with strings. They resemble somewhat the bamboo strip curtains (Fig. 22).

Cane bottoms. Cane bottoms are often to be found. They are of the same size as the draining boards and are used as supports for the cheese during ripening (Fig. 23).

EQUIPMENT OF RIPENING ROOMS.

The only equipment of ripening rooms is the shelves on which the cheeses rest, and means for controlling at all times the temperature and moisture of the rooms. The shelves are made of hard wood, being about 5 inches apart so as to allow the boards and cheeses to slide in and out freely. They are built from floor to ceiling in order to economize space. Steam and brine pipes will best furnish means of controlling temperature and moisture.

CLEANLINESS, CONDITIONS, AND CONSTRUCTION OF ROOMS IN GENERAL.

Making room. One of the first requirements is that of absolute cleanliness. The floor should be of cement or some other water-tight material, and should slope toward a drain pipe, so that it can be readily flushed with water. The walls can be made of wood or brick, preferably the latter, and should be covered with whitewash or enamel paint. This coat of whitewash or paint should be renewed from time to time after cleaning off any dirt that may accumulate, and also for the purpose of disinfecting the room if this should be needed.

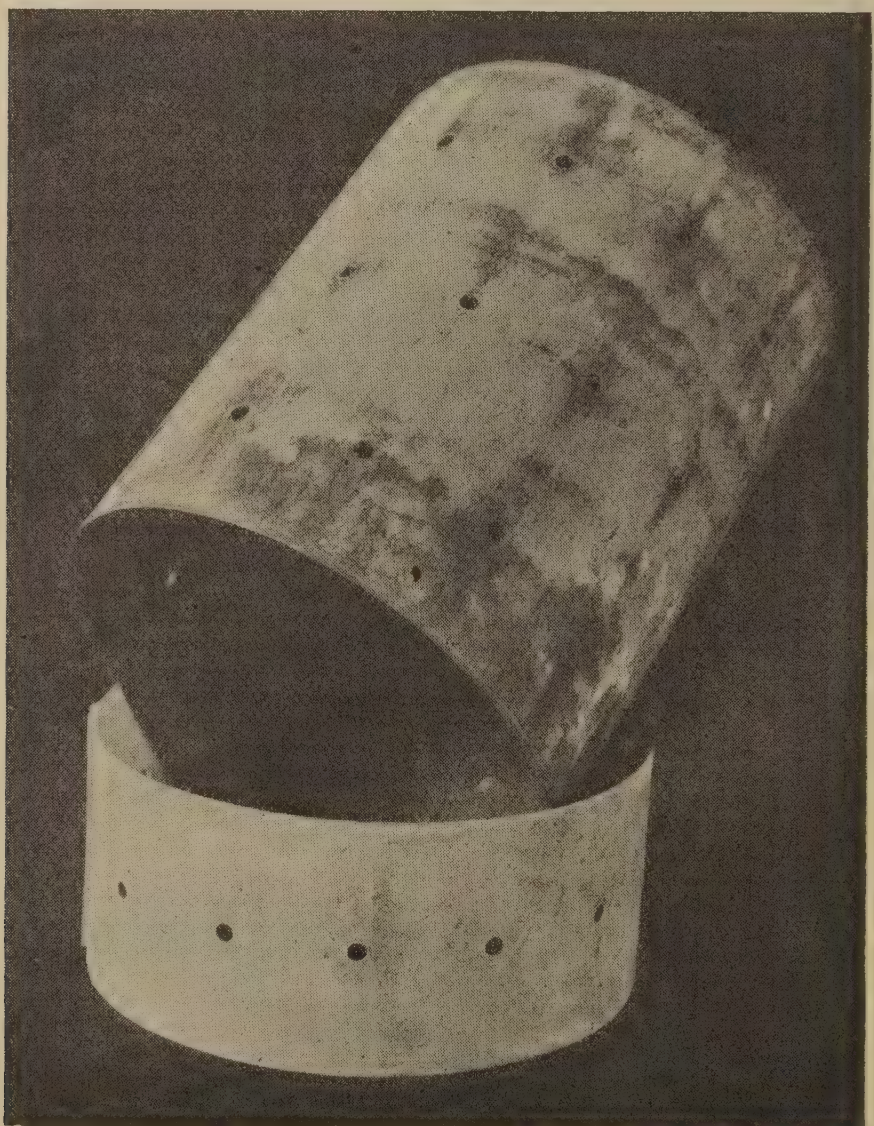

FIG. 20—Large and small forms.

The room must be frequently ventilated, no matter what the temperature of the outside air may be, and yet it is to be maintained at a constant temperature. For this purpose steam should be provided, as stoves or other heating arrangements do not warm the room as quickly or satisfactorily.

An ordinary dairy sink with water and steam taps is necessary. The steam pipe should connect with the water pipe by a tee, so that the water can be heated to any desired temperature.

As the tools cannot be cleaned properly with hot water alone, it is advisable to provide a steam chest or sterilizer of some sort where they can be left in contact with live steam.

A strong wooden box lined with galvanized iron and having a valve at the bottom as an outlet for condensed water has been found to be very satisfactory. It is provided with a strong cover, which can be fastened to the box with clamps. The whole arrangement should be made so as to stand a slight pressure. This box is especially useful for sterilizing the boards and cane bottoms used to hold the cheeses during the ripening process.

FIRST RIPENING ROOM.

The first ripening room must be nearly saturated with moisture and kept at a temperature of about 60-62° F., as these conditions are most suitable for the proper growth of mold.

SECOND RIPENING ROOM.

This room is to kept somewhat cooler (56-60° F.), as the ripening proceeds more uniformly at this temperature. Here it is not necessary to keep such a high percentage of moisture as in the first room. There should be just enough to keep the cheeses from drying out.

The walls and floors of both of these rooms should be like those of the making room; that is, easy to clean.

Both of the ripening rooms should be well ventilated and steam heated. The steam can be used not only for heating, but also for maintaining the desired degree of moisture.

In summer the outside heat would raise the temperature of the rooms, causing the cheese to ripen too fast and not uniformly. For that reason, some means of cooling must be provided.

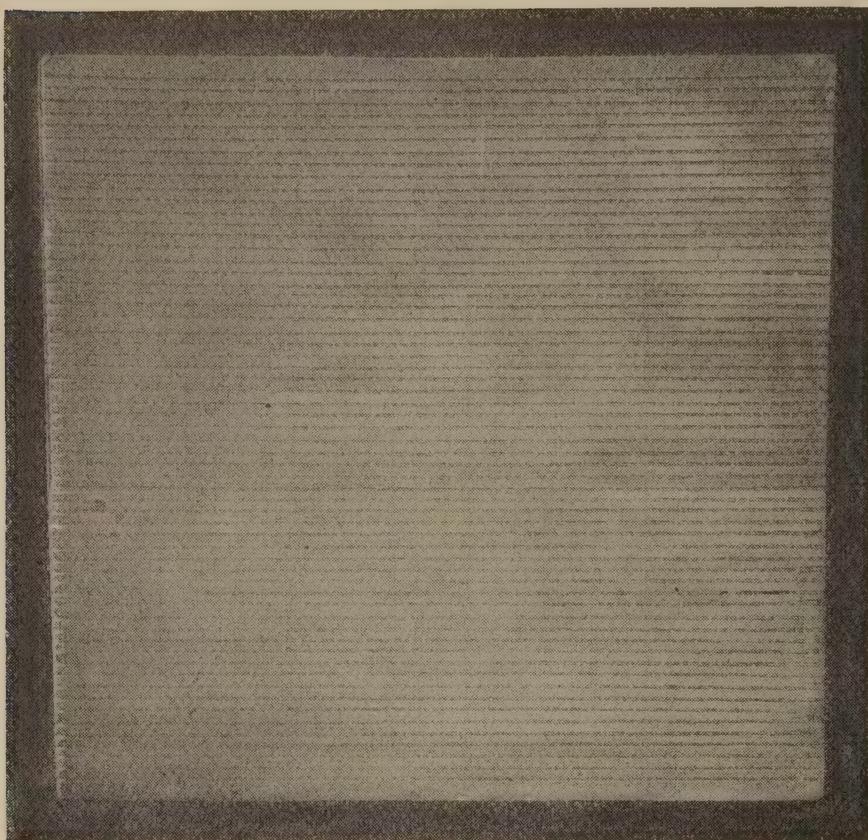

FIG. 21.—Draining board.

PROTECTION AGAINST INSECTS.

A very important item is that of protecting the cheeses against flies and other injurious insects.

The outer doorways, the windows, and every other possible opening should be carefully guarded by screens with as fine a mesh as can be procured, as the smallest flies produce the most trouble. If this is not carefully attended to, the cheeses are sure to become filled with fly maggots.

In the ripening rooms protection against these insects can be secured to a considerable extent by keeping the rooms dark; for flies will not readily breed and multiply in a dark place.

THE MAKING OF THE CHEESE.

Milk. The milk used in making Camembert cheese should be of the best quality, that is, clean and fresh. Two quarts of milk are required for each cheese.

Ripening. The milk is poured into the vat and by aid of water and steam is heated to 85° F., this being the temperature best suited for the growth of the lactic bacteria. A starter is added, the amount depending upon its strength and capacity for developing lactic acid, usually 3 quarts of a medium starter for every 100 pounds of milk.

It is best to use a starter which is a pure culture of lactic organisms, prepared by inoculating sterilized milk with these bacteria. In cheese and butter making some home-made starter is generally used, such as sour milk or buttermilk. These often give excellent results, but are by no means pure cultures, and cannot be depended upon. In fact they sometimes cause considerable trouble. After adding the starter the milk is allowed to stand until the desired degree of acidity is reached.

This method of ripening the milk before setting is not the general rule in France, where they generally set the milk at a very low degree of acidity without the previous ripening of the milk. The acid, however, develops later in the curd while the cheese is draining. In our experience serious trouble from gas has been avoided by ripening the milk before setting. Especially during the hot weather it is advisable to use a

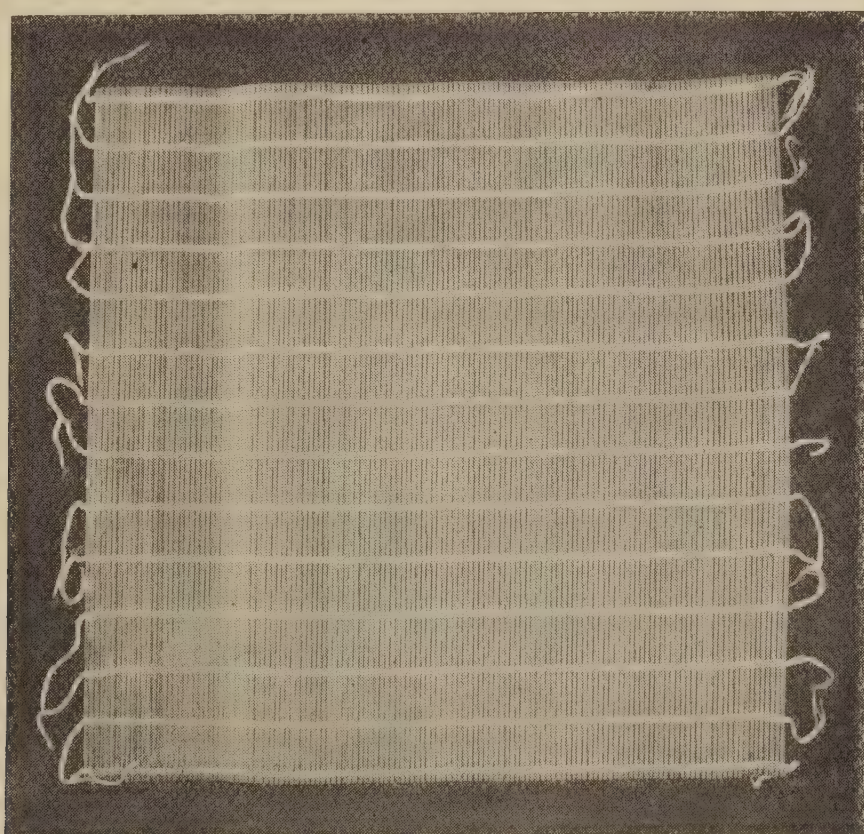

FIG. 22.—Draining mat.

higher degree of acidity. The percentage of acidity used by us is rather high. This is, however, partly because of the low temperature of the room in which our experiments are made. In France the making rooms are generally kept quite warm and the cheese will naturally drain faster there and develop the acid in the curd.

Several experiments have shown us that it is not entirely necessary to use such high degree of acidity to secure a properly drained cheese, but by using a starter which will work rapidly after the cheese is dipped, very satisfactory results have been obtained. The milk in such cases was ripened to only about 0.2-0.25 per cent. of acid.

KIND OF STARTER.

The various commercial starters have been used here and have produced excellent cheese of a mild type. The one found most satisfactory, however, was prepared from a certain brand of imported cheese. This cheese has a peculiar flavor of its own which differs from that of any other brand. Experiments to produce this flavor have been carried out here. After many of these imported cheeses had been carefully examined and analyzed a certain kind of lactic acid organism was found by the bacteriologist. This organism was separated and from it a pure culture starter prepared, which was used in the making of the cheese with excellent results. The flavor sought for has been produced repeatedly with this starter. As this brand of cheese is more popular than almost any other, this starter is probably the best that can be used in the manufacture of this cheese.

Adding Rennet. The milk while ripening, unless watched carefully, cools down and must be brought back to the same temperature as at first (85°F.) before adding the rennet. At this temperature it has been found necessary to use a curdling time of one and one-half to two hours to secure the texture of the curd desired for Camembert cheese. The amount of rennet required to curdle the milk in this time is calculated by means of the Marshall rennet tester or the titration apparatus.

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[1] As soon as a demand for this starter arises in the trade, cultures of it will be furnished to such companies as regularly supply starters for other creamery work.

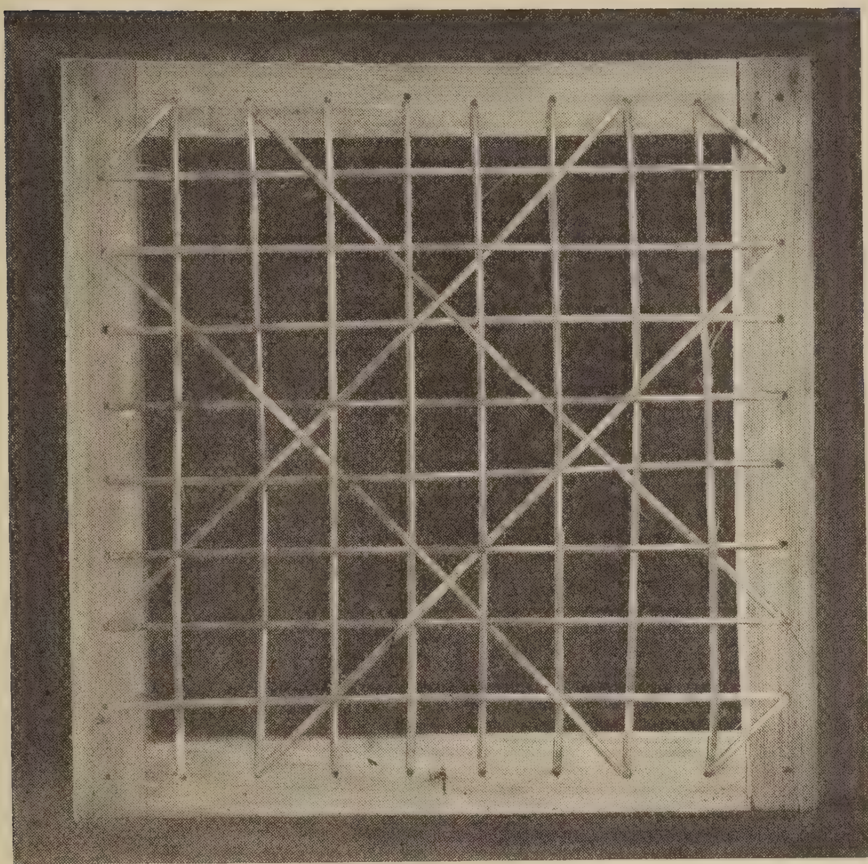

FIG. 23.—Cane bottom for ripening cheese.

Cut Curd. In France the method generally used consists in dipping the curd directly into the forms. Equally good results, however, have been obtained here with the curd cut. In cutting, the curd knife is passed through the curd in the vat in two directions at right angles, thus producing vertical columns of curd.

When the curd has been cut in this way, it drains faster and for that reason a lower degree of acidity is used than with the curd uncut. The most satisfactory acidity with cut curd has been found to be 0.3-0.35 per cent. If it is less, the curd is likely to be too soft; if higher, the curd will drain too rapidly, will become hard and compact, and will not ripen properly. The acidity is tested as follows: A sample of milk is taken with a Babcock pipette holding 17.6 cc. and is transferred to a glass or beaker. A few drops of phenolpthalein are added, and n-10 Na O H is run in from the burette, drop by drop, until a pink color just begins to appear. The number of cc. of soda solution used, divided by twenty, gives the percentage of acid in the milk. The higher the acidity the less rennet it takes. In case the acidity is 0.3 per cent., it will

take about 8-10 cc. of the ordinary rennet extract to every 100 pounds of milk to bring the curd to the right consistency in 1½-2 hours. The necessary amount of rennet is poured into a glass of water and then mixed thoroughly with the milk. The milk is now left to stand until it has coagulated to the proper consistency.

It is impossible to describe any test which will show when the curd is firm enough. This can only be shown by practical demonstration and after a little practice the maker can generally tell just when the curd is ready to cut. The curd of Camembert cheese is much firmer than that of Cheddar or Swiss cheese.

After the curd has been cut it is stirred gently once or twice with the dipper to separate the columns and hasten the separation of the whey. Then it is allowed to stand for about 15 minutes to make it a little firmer. The whey separates out at the surface and the bulk of it is dipped off.

If, however, the curd is quite firm, less of the loose whey is dipped off. The contents of the vat are now stirred to insure uniformity, otherwise part of the cheese would be softer than the rest.

Dipping. The next operation is the dipping. This is done with a ladle which just fits into the forms. Place the draining table near the vat, and upon it arrange the boards covered with mats and each holding nine of the forms. To each of these forms a dipperful of curd is added, taking care to bring the dipper inside the forms in order to prevent splashing and breaking of the curd.

After one dipperful is placed in each form the operation is repeated, another dipperful of curd being placed in each form in the same order as before, the dipping continuing until the forms are all filled to the top.

The cheese is now allowed to drain without any artificial pressure for four or five hours. At the end of this time it has shrunk to about half the original volume and is ready for inoculation of molds and turning.

After the curd has all been dipped into the hoops, the latter are piled up, together with the boards, one upon the other. This is done partly to save space and partly to cover up the cheese and thus keep off any dirt or flies which otherwise might fall upon them. The very top of the pile is then covered with an extra board (Fig. 24).

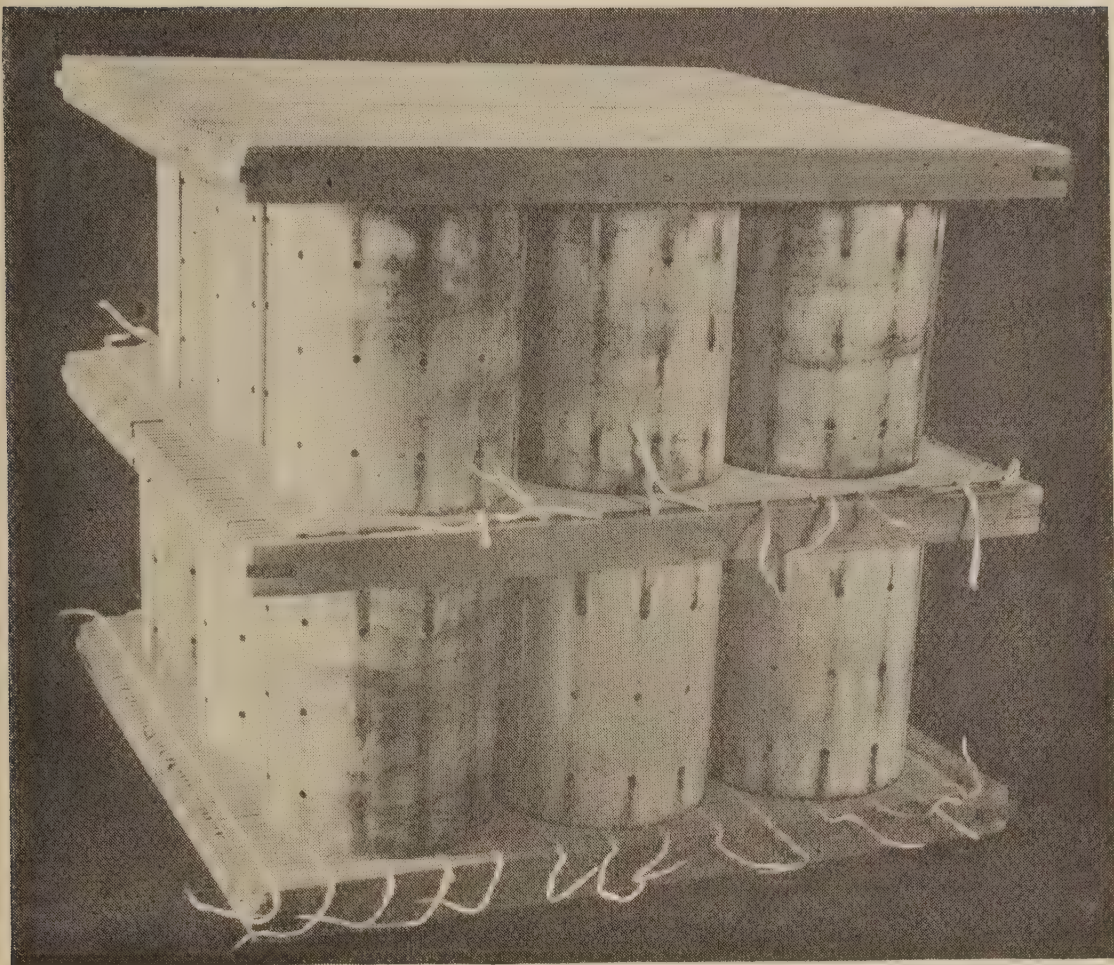

FIG. 24—Cheese boards, mats and forms as arranged for draining cheese.

INOCULATION AND TURNING.

Although it is not customary for French cheesemakers to inoculate Camembert cheese with mold, we have found it very desirable. Under the conditions found in Normandy the cheese acquires its moldy covering by accidental inoculation rapidly enough. Even then undesirable molds often appear and complicate matters to the injury of the cheese. In our experimental work definite inoculation on the day of making has been necessary to secure satisfactory results.

Where dependence is placed upon accidental inoculation undesirable molds often get on the cheeses ahead of the Camembert mold, with the result of either a poor cheese or one spoiled entirely. On the other hand, if a cheese is inoculated with the Camembert mold at the outset, this will grow and cover the cheese rapidly, which practically protects the cheese from the infection of other molds. A very good

proof of this statement is that one can almost always find some other species of molds on imported cheese, while the inoculated cheeses are generally pure cultures, unless the culture they were inoculated with was of poor quality. It is necessary that the maker know the right mold when he sees it.

A most satisfactory way of inoculating is as follows: Take a small jar with a tin cover which has been punched full of small holes, like an ordinary pepper box. Fill it half full of water, add a piece of moldy cracker or a piece of cheese with a good growth of the proper mold, and shake thoroughly. The contents of the jar are now sprinkled upon the surface of each cheese, then the cheeses are turned and inoculated in the same manner on the other side.

Another simple and very convenient way of inoculation, especially adapted to use in large factories, consists in taking two cheeses well covered with mold, and knocking them together over the hoops. In this way enough spores drop upon the cheese to give good results.

This inoculation is by the "Penicillium Camemberti," but a second mold, Oidium lactis, seems to be necessary for the production of flavor in Camembert cheese, as has been indicated in a previous paper.

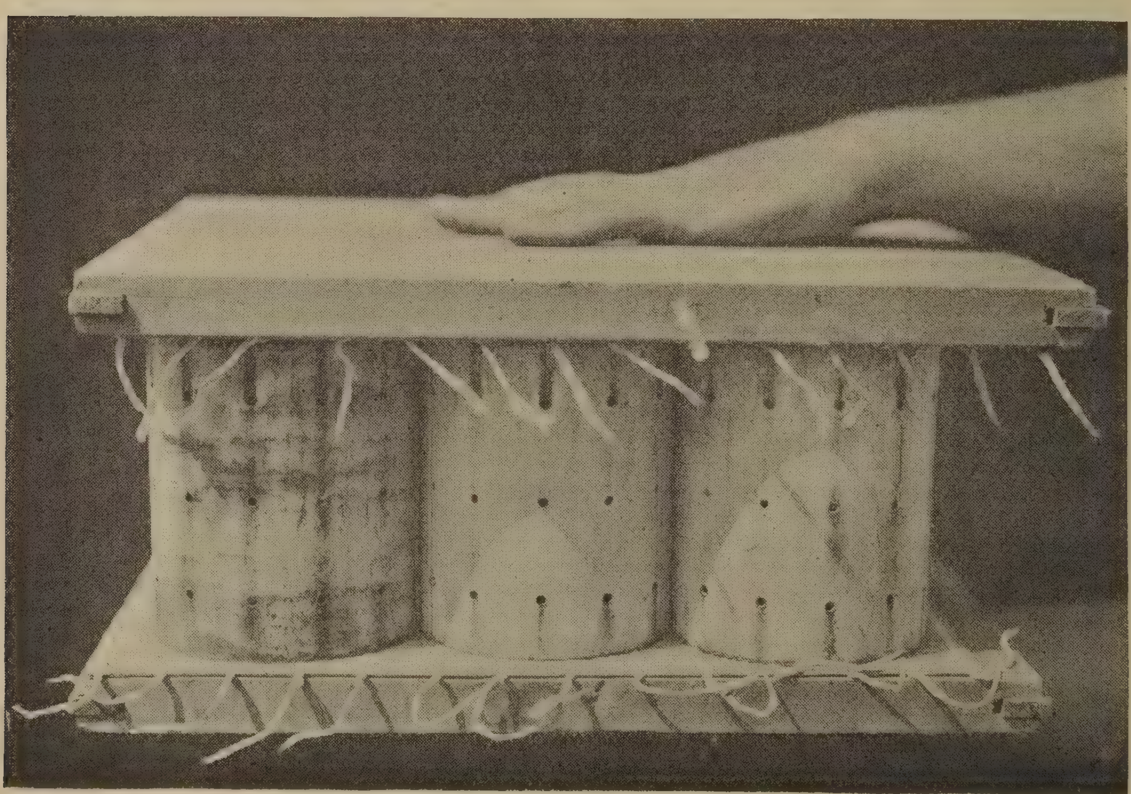

Fig. 25—Method of turning cheese.

The latter is mostly found in milk and will appear on the cheese slowly. To insure its rapid growth the cheese may be inoculated with it also. The same method may be employed except that this mold is grown in gelatin culture medium instead of upon crackers.

The cheeses are turned not only to secure the inoculation of both sides, but also to prevent them from becoming too compact on the under side on account of the greater pressure there, and to insure a smoother surface on both sides.

The quickest and easiest way to turn the cheeses is to cover the nine forms with a second mat and another board. Place one hand under the lower board and the other over the upper, and then invert (Fig. 25). If the cheeses thus turned do not rest flat on the bottom, they are straightened out by moving the forms. After turning and inoculating, the cheeses are left without any further handling until the next morning, when they are taken out of the forms and salted.

By this time they have shrunk almost to their final size. In case they are not yet hard enough to be safely handled, they are turned again and left to stand until they are sufficiently firm.

SALTING.

The salting is done by taking two cheeses together, just rolling the edges and then rubbing their surfaces in salt. The salt to be used should not be too fine, as this would produce over salting (Frontispiece).

After salting, the cheeses are placed upon dry boards so that the sides which were previously at the top will now be at the bottom. The next morning it will be found that all of the salt has dissolved and that most of it has diffused into the cheese. The cheeses are again transferred to another dry board or cane bottom, after turning, and are ready for the ripening process. The reason for transferring them to dry boards is that a dry board is less apt to become covered with mold.

UNCUT CURD.

A cheese from uncut curd is made somewhat differently. Although the cut curd drains more rapidly, the draining of the uncut curd can be greatly facilitated by allowing the milk to become more acid before adding the rennet.

In our experiments the degree of acidity giving the most satisfaction in the uncut curd has been about 0.40-0.45 per cent. The amount of rennet to be added varies inversely as the acidity. When the curd has reached the proper consistency, it is dipped into the hoops in the same way as the cut curd, only the operation should be carried out more slowly. After the forms have been filled, the cheeses are allowed to stand without turning until the next morning. This is because the successive dipperfuls of uncut curd do not stick together readily at first and must be given more time.

While turning the cheeses the next morning they are to be inoculated. They must then be left until the following morning, by which time they are ready to be salted. After salting they remain another day in the making room, making three days altogether, instead of two as in the case of the cut-curd cheese.

Both cut and uncut curd cheeses should be hard enough to bear handling at the time of salting, but often they are not yet hard enough to retain their shape. In such cases they should be put at the time of salting into the small forms, where they remain until the next morning, when they can hold their shape without the aid of the forms, they are taken to the ripening room.

In France the cheeses are always made of uncut curd, but no reason has ever been given for the fact. In a series of experiments where cheeses were made of the same milk with cut as well as uncut curd for comparison, we have found that in almost every case the uncut curd cheese even when fully ripe did not decompose as quickly as the cut curd cheese. Another advantage is the fact that more cheese is produced from the same amount of milk and the loss of fat in the whey is not so great.

RIPENING OF THE CHEESE.

The cheeses are removed to the first ripening room. Here they are placed upon the shelves with the boards on which they rest during the whole ripening period. The boards are of the same size as the draining boards, but have a smooth surface. Cane bottoms are frequently used and are preferable to the boards for the following reason:

When boards are used the molds are apt to grow into the wood, causing the latter to stick so tenaciously that on turning the cheeses over, the rind is torn off. On the other hand, when cane bottoms are used the mold can grow more uni-

formly on both sides of the cheeses, and as they do not stick to the bottoms so tenaciously, it is necessary to turn them but once or twice in the first room, which reduces the labor considerably. The cheeses resting on boards must be turned daily.

FIRST WEEK OF RIPENING.

During the first week any ripening which occurs is not noticeable, but the cheese remains in the form of hard curd. The surface of the cheese often becomes slightly slimy, and some change in the color can be noticed. Towards the end of this first week the mold can be seen upon looking closely.

SECOND WEEK OF RIPENING.

During the second week the mold, when once started, grows very rapidly; and in the course of one or two days it covers the cheese completely, giving it a snow-white, cottonlike appearance. This white coat of mold turns to a grey green within two to four days, and by this time the cheeses begin to show actual ripening. The cheese grows softer just under the coat of mold, and the ripening proceeds gradually toward the center. On cutting the cheese open now, a thin layer of softened curd can be observed under the mold. The texture of this ripened part is creamy and soft, just as the whole cheese will be at the time of complete ripening.

If the cheeses remain upon the shelves in the ripening room under proper conditions, as they often do in France, they will ripen completely. But under our conditions, where the air is dryer, we have found it necessary to wrap the cheeses during the second week in parchment paper or tin foil . This prevents evaporation and hardening, checks the growth of mold, and promotes the growth of the other organisms, thus hastening the ripening.

When the cheeses appear dry and tend to become hard, tin foil seems to give the better result. But in the factories in the trade, parchment paper is nearly always used. The cheese wrapped in tin foil very commonly develop stronger flavors and softer texture than those wrapped in paper. The time of wrapping affects the kind of cheese produced. If a cheese with a strong flavor is desired, the wrapping must be done when the cheese is slightly covered with the white mold. On the other hand, a mild flavor can be obtained by wrapping the

cheese after the growth of mold has become luxuriant and has turned blue. The intensity of the flavor can be partly regulated in this way. A higher flavor is produced by early wrapping, because the growth of Camembert mold is thus somewhat checked, giving another mold, Oidium lactis, an opportunity to develop.

After being wrapped the cheeses are returned to the boards and shelves. Often they are put in small, round boxes* in which they fit tightly, and in which they are later shipped to market. These boxes help to maintain the shape of the cheeses, which become quite soft during ripening. The cheeses are now transferred to the second ripening room, where they remain until they are ready for shipment, or, if desired, until they are fully ripe. During the third week the ripening proceeds rapidly, and the cheeses become one-half to two-thirds ripe. On the surface slimy reddish spots appear, and the cheese begins to give off a characteristic Camembert odor. Between the third and the fourth week the hard curd in the center disappears, and the cheese has a creamy, waxlike texture. The delicious flavor found in all Camembert cheeses is now evident. A little hard curd may still be found in the center of the cheese, but this will disappear if given time.

In factory practice in France and also where these cheeses are now made in America, they are wrapped and put in boxes as soon as the covering of mold is well started. This is when they are about two weeks old. Instead of ripening further in the factory, they commonly are sent to market at once. Further ripening thus becomes a matter for the dealer. Although this is the common practice in France, some factories ripen the cheese quite fully to supply a special trade. In other cases dealers establish cellars, where the cheeses are taken out of the boxes, are unwrapped, and are ripened completely on shelves before selling. Others allow them to ripen as they may in the boxes. It seems desirable to recommend that where domestic factories are supplying our own market, cheeses be ripened far enough to guarantee good results before they are sent out of the factory.

VARIOUS TROUBLES ENCOUNTERED.

Gassy Curd. In the making of Camembert cheese, as in making any other kind, numerous difficulties are encountered. One of the most common troubles is that arising from gassy curd. In this case the fault generally lies in the milk, being

*These boxes should be about one-eighth inch smaller than cheese forms.

due to gas-producing bacteria. No way has been found in which this difficulty can be absolutely avoided, but it may be partly remedied by the use of a good lactic starter and high development of acid before setting, which will in time overpower the gas-producing organisms. If the curd is kept at a low temperature after dipping, the growth of these gassy organisms is checked to some extent. The gas cannot always be seen in the fresh curd, but sometimes develops later, and if it does the cheese very seldom turns out satisfactorily (Fig. 26).

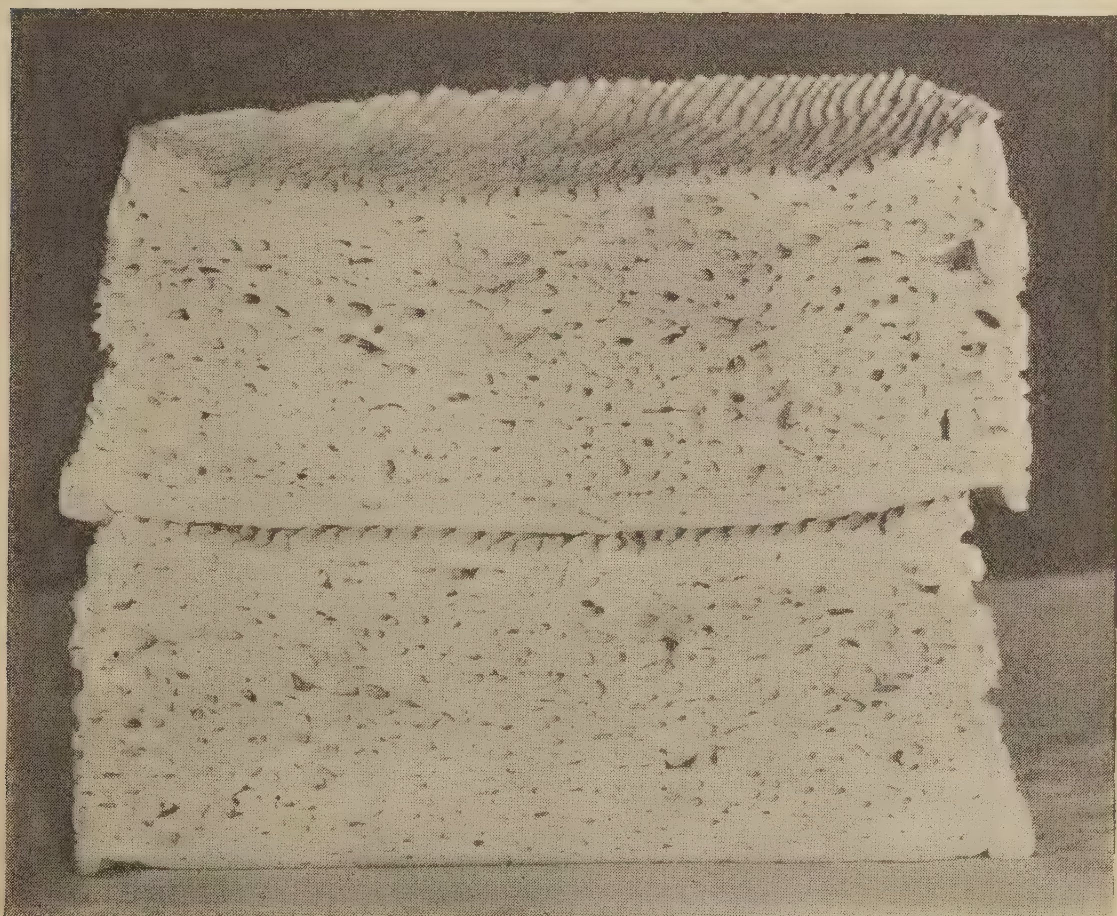

FIG. 26—Gassy curd.

YEAST.

Another difficulty is caused by yeast. The cheeses often become covered with yeast in the making room, although sometimes the yeast makes its appearance after the cheeses have been taken to the ripening room. The surface of such cheeses become slimy and sticky, causing the cheeses to stick

to the boards, so that when they are turned a thin skin is torn off. In such cases it is difficult to obtain a good growth of mold, for the latter is pulled off with the thin film of yeast, the cheese does not ripen properly, and it often has a strong, bad flavor.

MOLDS.

Contamination from the other varieties of mold causes considerable trouble. If the cheeses contain spots of green mold or brown, or if a long, fuzzy mold, sometimes with black tops (Mucors) appears, the Camembert mold cannot grow properly, and the result is often a bitter cheese or one with other undesirable flavors. The Camembert mold will sometimes grow over and cover the green and other molds, but this does not prevent them from producing an objectionable flavor.

When such infection from foreign molds occurs, the whole equipment should be sterilized, and if possible the walls and floors of the making as well as the ripening rooms should be cleaned and whitewashed.

DRY CHEESE.

The drying out of cheese is caused by lack of moisture in the ripening rooms, or by too rapid draining of the curd. Such cheeses can often be saved, if the drying out has not proceeded too far, by wrapping them tightly in tin foil.

WET CHEESE.

A defect just the opposite of the last is found in wet cheeses. It is caused by too low a temperature of the making room, as well as by too low a degree of acidity of the milk, both of which retard the draining of the cheese. It may also be caused by too high a degree of moisture in the ripening rooms.

The ripening of such cheeses is more in the nature of a liquefaction, and the interior becomes so soft that it would run out if the cheese were not kept in a box. There is *no* hope for such cheeses, as the flavor and texture will never be satisfactory.

MITES.

Serious damage is done to cheeses by the cheese mite, a small insect, scarcely visible to the naked eye. These mites crawl all over the cheese, and eat up or destroy the mold, so that the cheeses will not ripen properly, and is practically ruined. The only remedy in such cases is the thorough disinfection of the whole plant.

SKIPPERS.

Another enemy of the cheese is the cheese skipper, the larva of a small fly. The flies lay their eggs on the cheese, and these hatch out in a short time. The skippers remain on the surface and can be scraped off, but not without spoiling the appearance of the cheese and possibly leaving unhatched eggs. Such cheeses cannot be sold and are practically lost.

APPENDIX.

ESTIMATED EQUIPMENT OF A FACTORY USING ABOUT 1,000 POUNDS OF MILK PER DAY.

Before building such a plant it is always desirable to visit some dairy establishment where the essential equipment would be as nearly comparable to that needed as possible. This need not necessarily be a Camembert cheese factory. Any properly equipped dairy establishment will give ideas as to the arrangement of steam and water pipes, vats, etc.

In addition to this ordinary creamery equipment, a Camembert cheese factory requires its own special apparatus.

Calculated for 1,000 pounds of milk, which will produce 250 cheeses, this will require for the making room:

1. 250 high hoops.
2. 500 low hoops.
3. 150 draining boards (if used in making room only).
4. 150 mats.
5. Draining table to accommodate 250 cheeses (42 square feet of surface).
6. Shelf room enough to accommodate 250 cheeses on the second day of draining.

Vats and draining table should be so arranged as to minimize the labor of dipping.

The two ripening rooms must be large enough to accommodate the entire output for about 20 days, i e. 5,000 cheeses.

If the cheeses are kept on boards such as are used in the making room, this would require about 500 boards in constant use. These would occupy 700 running feet of shelving. The shelves should be about 5 inches apart. A rough calculation will show that a room 14 x 14 x 8 would be large enough to accommodate all the cheeses. The arrangement of shelving is a matter of economical utilization of all the available space. Aisles between the shelves should be at least 3 feet wide to give sufficient room to do the necessary work. It probably would require a maker and one helper to run such a factory.

STORRS

Agricultural Experiment Station,

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BULLETIN NO. 48, MAY, 1907.

COMPARATIVE STUDIES WITH COVERED MILK PAILS.

BY W. A. STOCKING, JR.

BOARD OF CONTROL.

Note.—The Author resigned his position as Bacteriologist of this station Sept. 1st 1906, in order to accept the position of Asst. Professor of Dairy Bacteriology in the New York State College of Agriculture at Cornell University, Ithaca, N. Y.

Publications of the Station

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The following publications of the Storrs Agricultural Experiment Station are available for distribution, and, as long as the supply lasts, will be sent free to all who desire them.

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No. 7. Chemistry and Economy of Food.
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No. 14. The Elm Leaf Beetle.
No. 21. The Ripening of Cream.
No. 23. The Relation of Bovine Tuberculosis to that of Man and its Significance in the Dairy Herd.
No. 25. The Covered Pail a Factor in Sanitary Milk Production.
No. 26. The Relation of Temperature to the Keeping Property of Milk.
No. 27. Poultry as Food.
No. 28. Dairy Observations.
No. 29. Records of a Dairy Herd for Five Years.
No. 30. Spraying Notes for 1903.
No. 31. Food Value of a Pound of Milk Solids.
No. 32. Protecting Cows from Flies.
No. 33. A Successful Brooder House.
No. 34. Discussion of the Amount of Protein Required in the Ration for Dairy Cows.
No. 35. The Camembert Type of Soft Cheese in the United States.
No. 37. The So-called "Germicidal Property" of Milk.
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No. 41. Spraying Notes, 1904-1905.
No. 42. Quality of Milk Affected by Common Dairy Practices.
No. 43. The Facility of Digestion of Foods a Factor in Feeding.
No. 44. Poultry Observations.
No. 45 The Apple Leaf Miner.
No. 46 Directions for Making the Camembert Type of Cheese.
No. 47 Comparative Studies with Covered Milk Pails.

REPORTS.

The Reports of the Storrs Agricultural Experiment Station for 1889, '90, 94 (Part III.), '95 (Part III.), '96 (Part II.), '98, '99, 1900, 1901, 1902-3, 1904, 1905, 1906, are available for free distribution.

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COMPARATIVE STUDIES WITH COVERED MILK PAILS.

BY W. A. STOCKING, JR.

The demand for a good wholesome grade of milk produced under sanitary conditions is steadily increasing. People in the cities are taking more and more interest in the sanitary quality of the milk which they use in the household. The general awakening in regard to the sanitary qualities of milk which has taken place in the last few years can be attributed chiefly to two causes. The first of these is in harmony with, and a part of the general desire on the part of consumers for pure and wholesome food products of all kinds and the milk supply has come in for its share of investigation. The general supply of the cities has been studied, methods of transportation have been considered and more recently the conditions existing upon the farms where the milk is produced have come in for their share of investigation.

The second reason for the growing interest in cleaner milk lies in the results of the investigations already conducted. It has been found that a considerable part of the milk sold to consumers has been of very poor quality when considered from the standpoint of wholesomeness. Much of it has been shown to contain relatively large amounts of dirt, its germ content being at the same time abnormally high and frequently containing putrefactive and other undesirable species of bacteria. As a result of this work together with the knowledge that milk may frequently be the carrier of various forms of bacterial diseases and that nearly all kinds of bacteria grow and multiply with great ease in milk, the importance of carefully guarding milk against the entrance of undesirable bacteria has become generally recognized. The ordinary market milk which reaches the larger cities normally contains high numbers of bacteria. These are the result either of more or less dirty conditions in the production of the milk or of too warm a temperature after the milk has been pro-

duced or a combination of these two conditions. It is perfectly possible to produce milk containing a very low number of bacteria, a fact which has been demonstrated by many producers of so-called "sanitary" or "certified" milk. Consumers in general at the present time are not willing to pay the increased price charged for the so-called "certified" grades of milk which are now available in practically all cities. It is not to be expected that producers in any kind of business will sell their products for less than the cost of manufacture or production plus a small margin of net profit and with the present high prices for feeds and farm labor the cost of production can not be materially increased without increasing the price of the product. It is hardly to be expected that milk consumers in general will be willing to pay much higher prices for their milk than they have been accustomed to paying. It is only as their knowledge of actual conditions increases and they appreciate more fully the value of wholesome milk that they can be expected to pay more for their milk. It is not reasonable to expect that this change will be brought about rapidly. The increase in the demand for milk of high grade at a considerably increased price will, therefore, be relatively slow. Meanwhile health boards and city officials are requiring a gradual improvement in the general milk supply. This will necessitate the shutting out from the market the product of an occasional producer who will not comply with the necessary standards for the production and handling of his milk. Most dairymen, however, are very willing and ready to improve the quality of their milk if it can be done without materially increasing the cost. In order to produce and deliver to the consumer a good wholesome grade of milk it is necessary to have a healthy herd kept in good healthful stable conditions. The milk must be kept as free as possible from dirt contamination and the product must be immediately cooled and held at a temperature low enough to prevent the rapid growth of bacteria. It is not the purpose of this article to deal with the general problems of sanitary milk production but simply to discuss briefly one of the important ways in which the cleanliness of milk may be increased. Most of the detrimental changes which occur in milk are caused by bacteria. The chief source of these organisms is the dust and dirt which fall into the milk, principally while the milk is being drawn from the cow and before it leaves the stable. Any means, therefore, for preventing the entrance of dirt into the milk during the process of milking will tend to improve the sanitary quality of the product. One

of the most practical devices used at the present time for the purpose of excluding dirt and bacteria from the milk during the process of production is some form of covered milk pail. The ordinary milk pail is about twelve inches in diameter and if it is entirely uncovered it is easy to see that a considerable amount of dirt might fall into the milk during the process of milking. If, however, this opening can be reduced to a small proportion of the entire area of the pail the amount of dirt which could fall in would be correspondingly reduced. The demand for some form of covered pail which is both effective in excluding dirt and bacteria and which is at the same time practical has resulted in the development of a number of styles of covered milk pails. The purpose sought in all of these is the same; namely, to reduce as far as possible the area through which dirt and dust can fall into the pail. The amount to which the opening can be reduced is necessarily limited because a certain sized opening is necessary for the practical operation of any pail. In the following pages of this article the writer desires to report the results of some tests made with some of the styles of covered milk pails which have come under his notice. This is not intended to be a complete test of the various forms of pails now in use for there are other styles which are not included in this report but these results are given with the hope that they may prove suggestive and useful to some dairymen. In Bulletin 25 of this Station the writer reported certain tests made with the Stadtmueller covered pail. Since the publication of that report considerable more work has been done with this pail and the results are here given in part.

GENERAL METHOD OF THESE EXPERIMENTS.

In all of the experiments reported in this paper certain general methods were followed uniformly while the details varied somewhat according to the nature of the different tests. In all of the work the milk pails and other materials coming in contact with the milk were thoroughly sterilized in steam previous to use. In most cases the udder and flank of the cows were wiped with a damp cloth just before milking in order to remove any loose dust and dirt which might adhere to the cow. For this purpose the cloth was moistened in clean water without the use of any germicide. As soon as the samples were obtained they were taken to the laboratory where tests were immediately made. The number of bacteria

found in a sample of freshly drawn milk is an indication of the amount of external contamination which the milk has received. The numbers of bacteria contained in the different samples of milk is, therefore, used as a basis for determining the relative amount of dirt and dust which fell into the milk during its production. In order to determine the germ content each sample of milk was plated while fresh into litmus sugar gelatin and these plates were then allowed to develop at a constant temperature of 70°F. for six days. At the end of this time the colonies were sufficiently developed so that a satisfactory study of the plates could be made. In studying the plates the total number of bacteria, the number of acid producing species and the number of liquefying species were determined and also the principal species which the milk contained. The total number of bacteria contained by any sample is of importance as being an indication of the total dirt contamination which the milk has received. The acid organisms are of importance since it is the action of this group of bacteria which causes the souring of milk and the number of liquefying bacteria is of considerable significance because they indicate the source from which the dirt contamination has come, these species being commonly found in filth and putrefactive materials. In certain cases sub-samples were taken from the fresh milk and kept at a constant temperature to determine the keeping quality of the milk and the results obtained from these tests are given in connection with some of the experiments. Certain special methods employed in connection with the different groups of experiments will be discussed in connection with those tests.

EFFICIENCY OF A COVERED PAIL IN A WELL KEPT STABLE.

Table No. 18 gives the results of a series of tests in the College stable where the conditions of cleanliness are somewhat above those usually found in dairy barns. The stable itself is in the basement and far from ideal in location and construction but considerable care is taken to keep the stable and the cows clean. A photograph of the stable is given in the frontispiece. The Stadtmueller pail used in these tests can be seen in this picture.

Table 18.

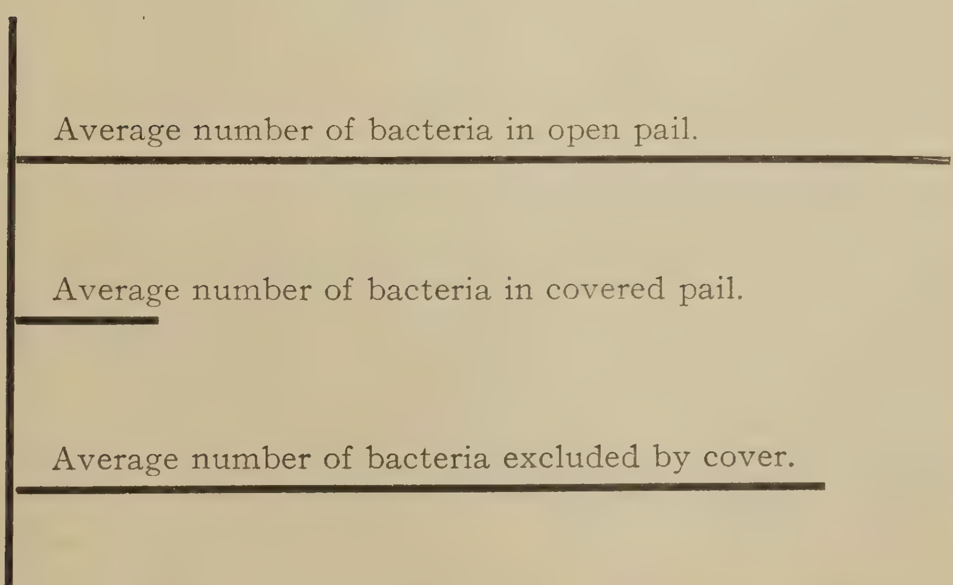
Effect of covered pail (Stadtmueller) in stable where considerable care is exercised.

A. Open Pail.

Date	Name of cow	Total bacteria	Acid bacteria	Liquefying bacteria
Nov. 6	Nellie...........	15,300	150	720
" 6	Sully...........	248,400	245,000	175
" 8	Nellie...........	13,300	2,300	550
" 9	Sully...........	3,700	———	170
" 11	Nellie...........	14,300	50	330
" 13	Sully...........	9,680	1,000	260
" 18	Nellie...........	30,200	20,900	350
" 20	Sully...........	4,300	1,460	280
	Average......	42,400	38,690	355

B. Covered Pail.

Date	Name of cow	Total bacteria	Acid bacteria	Liquefying bacteria
Nov. 6	Sully...........	7,750	0	850
" 6	Nellie...........	8,500	50	325
" 8	Sully...........	14,950	2,650	650
" 9	Nellie...........	1,100	———	75
" 11	Sully...........	1,775	100	100
" 13	Nellie...........	8,700	4,300	300
" 18	Sully...........	4,750	2,975	140
" 20	Nellie...........	3,900	800	300
	Average......	6,430	1,550	343



The first part of this table marked "A" shows the germ content of the milk drawn into an ordinary open milk pail and in part "B" of the same table is given the germ content of milk drawn into the same pail with a Stadtmueller cover, a cut of which is shown in Fig. 27.

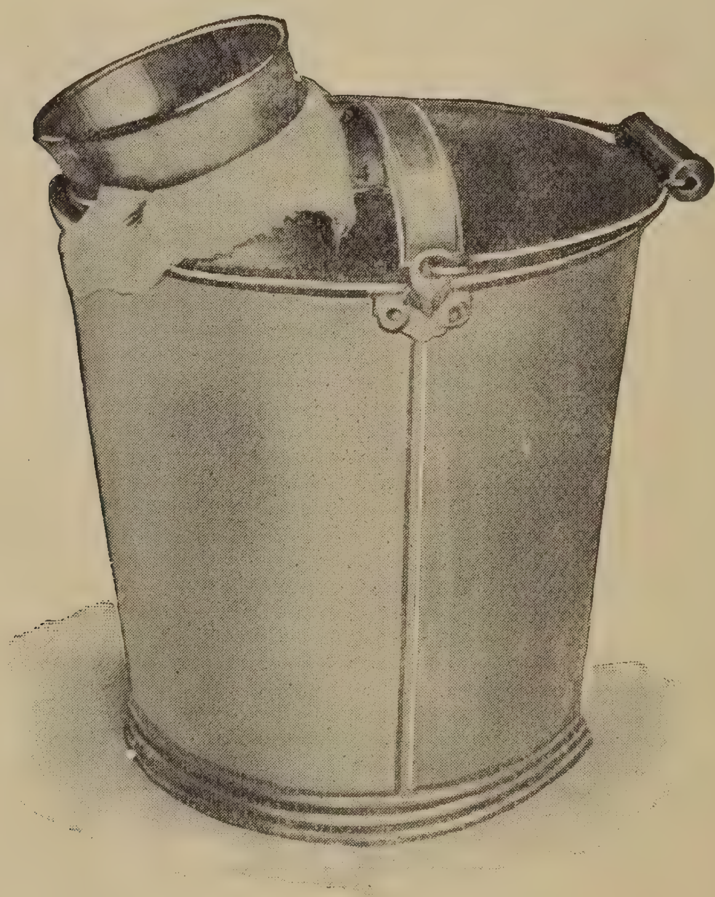


Fig. 27—Stadtmueller covered pail used in experiments given in Table 18.

The milk in these experiments was obtained from two cows. At one milking Nellie was milked into the open pail and Sully into the covered pail and at the next milking the order was reversed, Sully being milked into the open pail and Nellie into the covered one. By alternating in this way the difference in the germ content of the udders of the two cows is equalized in the experiments. A series of samples taken in this way should show with some accuracy the value of using this form of covered pail in a barn of this kind. It will be seen by comparing the experiments for the same day under "A" and "B" that in every case except one the milk drawn

into the covered pail contained considerably smaller numbers of bacteria than did the milk drawn into the open pail at the same milking. As would naturally be expected the difference in the germ content of the two samples varied on different days according to the condition of the stable. The averages for the two series of tests show that the covered pail contained on an average only fifteen per cent. of the number of bacteria which the milk from the open pail contained, or in other words the milk in the open pail contained six and one-half times more bacteria than did the milk from the covered pail. These average differences are shown graphically by the diagram accompanying the table.

VALUE OF THE HAYMAKER PAIL IN THE COLLEGE BARN.

The stable conditions under which these tests were made were the same as for the preceding series of tests. The pail used is shown in Fig. 28.

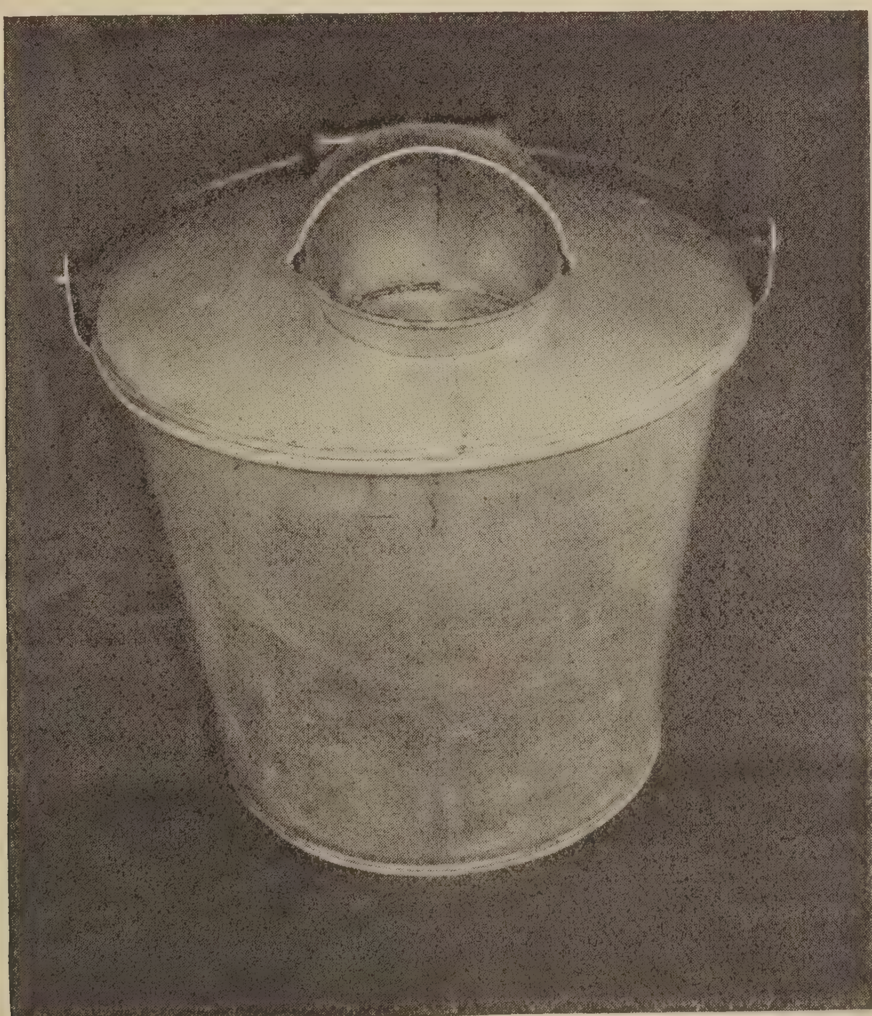


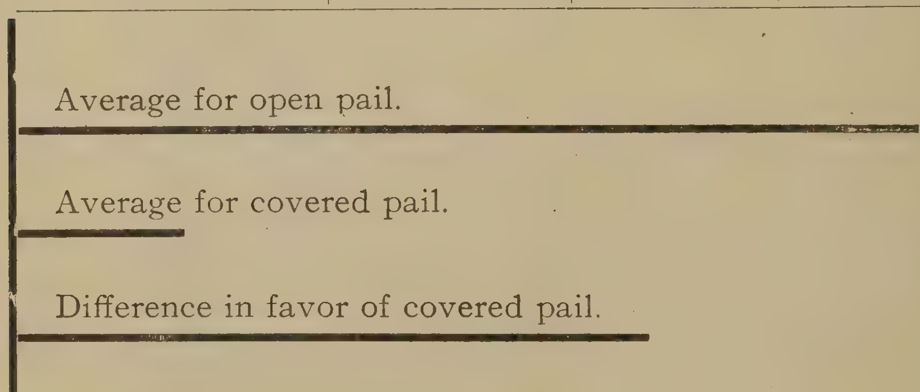
FIG. 28—Haymaker pail used in experiments given in table 19.

The cover carries an oval shaped opening partially covered by a sliding hood. This hood is movable for the purpose of regulating the size of the opening into which the milk is drawn. The form of this opening can be better seen in Fig. 37 representing the different parts of the strainer attachment used in the pail. In the tests given in Table 19, however, this strainer attachment was not used. These experiments were simply to determine the efficiency of the pail with the cover in comparison with the same pail without any cover. The results show that this form of cover is about as efficient in excluding contamination as the Stadtmueller pail just discussed. In these experiments the milk from the covered pail

Table 19.

Tests with Haymaker pail compared with open pail.

Date	Kind of pail	Total Bacteria	Acid Bacteria	Liquefying Bacteria
Feb. 8...........	Open	2,050	708	42
" 8...........	Covered	208	96	33
" 9...........	Open	1,258	300	137
" 9...........	Covered	758	229	13
" 17...........	Open	3,123	663	117
" 17...........	Covered	237	78	20
" 18...........	Open	633	46	75
" 18...........	Covered	150	42	0
" 19...........	Open	1,000	267	50
" 19...........	Covered	63	30	10
Average.........	Open	1,610	397	84
	Covered	280	95	15



contained decidedly smaller numbers of bacteria than did the milk drawn into the open pail at the same milking. The same method as described in the preceding series of tests was used for getting these samples; namely, one cow was milked into the pail with the cover and another one into the pail without the cover, the order of milking the two cows being reversed at the different milkings. The numbers of bacteria contained

in these samples of milk are quite low owing to the good condition of the stables. The samples from the covered pail, however, contain on an average only about 17 per cent. of the bacteria found in the milk from the open pail. In other words, the open pail allowed practically six times as many bacteria to fall into the milk as did the covered pail. In the diagram accompanying Table 19 these average differences are represented by the relative length of the straight lines.

After making these tests in the College barn the writer wished to determine the value of the covered pail in stables where the conditions of cleanliness were not quite so good as those maintained in this stable. Through the kindness of the owners it has been possible to make such tests in two other stables. One of these stables is shown in Fig. 29.

This is a basement stable opening to the southeast with a good abundance of windows. The stable floor is made of plank sufficiently raised from the walk behind to insure the cleanliness of the cows. The general construction of the stables is fairly good and the cows received considerable care so that they were entirely free from any adhering filth and

FIG. 29—Photograph showing stable where experiments given in table 20 were made. Conditions of cleanliness not quite so good as in College stable. (Photograph by Jarvis.)

were thoroughly groomed each day. The feeding was done just before milking and the cows were gone over with a stiff brush just previous to milking so that the stable atmosphere was more or less filled with dust. For this reason the conditions were not quite as good as those existing in the College stable where the preceding experiments were made. In these tests the Stadtmueller pail was used and the same method of obtaining the samples was followed here as in the experiments already described.

Table 20.

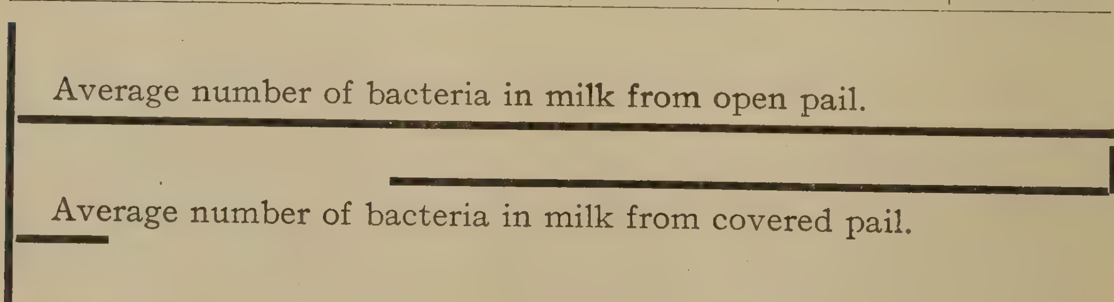
Effect of covered pail (Stadtmueller) in stable where conditions of cleanliness are above the average.

A. Pail without cover.

Date	Total Bacteria	Acid Bacteria	Liquefying Bacteria	Hours to Curdling at 50° F.
March 25	92,000	300	290	83
March 29	2,750	1,225	325	89
April 3	4,775	3,880	450	158
" 9	7,675	6,975	350	147
" 11	58,500	100	750	97
Average	33,150	2,490	430	115

B. Pail with cover.

Date	Total Bacteria	Acid Bacteria	Liquefying Bacteria	Hours to Curdling at 50° F.
March 27	1,250	200	50	107
April 1	1,560	700	137	197
" 7	387	212	37	185
" 16	4,950	2,000	870	113
" 18	550	75	75	89
Average	1,740	637	234	138



The results shown in Table 20, parts A and B, represent the germ content of the milk obtained in this stable. In this case the samples taken with and without the cover were not ob-

tained on the same day and for this reason the individual experiments are not so strictly comparable as in the preceding tables. The results of the series, however, should show the normal value of the two methods of milking. It will be seen that the samples taken into the covered pail contained decidedly smaller numbers of bacteria than did the milk drawn into the open pail. The averages for the two series show that the milk from the covered pail contained but slightly over five per cent. of the number of bacteria which the milk from the open pail contained. Put in another way these figures mean that the milk drawn into the open pail contained on an average nearly twenty times the number of bacteria that fell into the milk drawn into the covered pail. These results show a greater difference in favor of the cover than was obtained in the College barn where the atmospheric conditions were somewhat better. The conditions in this stable represent the conditions found in the better grade of dairy stables and the results obtained probably show the gain which might be expected in the sanitary condition of the milk in other stables of this grade. The average difference in the germ content between the milk drawn into the open pail and into the covered pail in this stable is strikingly shown by the difference in the length of the two lines given in the diagram following Table 20.

In Table 21 the results obtained by using the covered pail in another barn are shown. The exterior of this barn is shown in Fig. 30 which was made from a photograph taken of the barn and shows quite accurately the actual condition.

This barn stood with its longest dimension facing the south and the stables ran along the south side of the barn with the feeding alley in the center. There were no windows in this stable to admit sunlight and when the doors were closed the stable was entirely dark except for the light which entered through the numerous and ample cracks. The stable was not provided with a raised floor, consequently the cows were badly coated with filth. It was impossible to get a satisfactory photograph of the interior of this stable owing to lack of light but a poor picture of two cows which stood in front of the door was obtained and is given in Fig. 31.

The photograph shows the filthy condition of these cows. As would be expected under such conditions the milk produced contained very high numbers of bacteria, that drawn into the open pail in one case containing over 9,000,000 bacteria per cubic centimeter, the lowest number on any day for the open pail being 115,000 bacteria per cubic centimeter. By

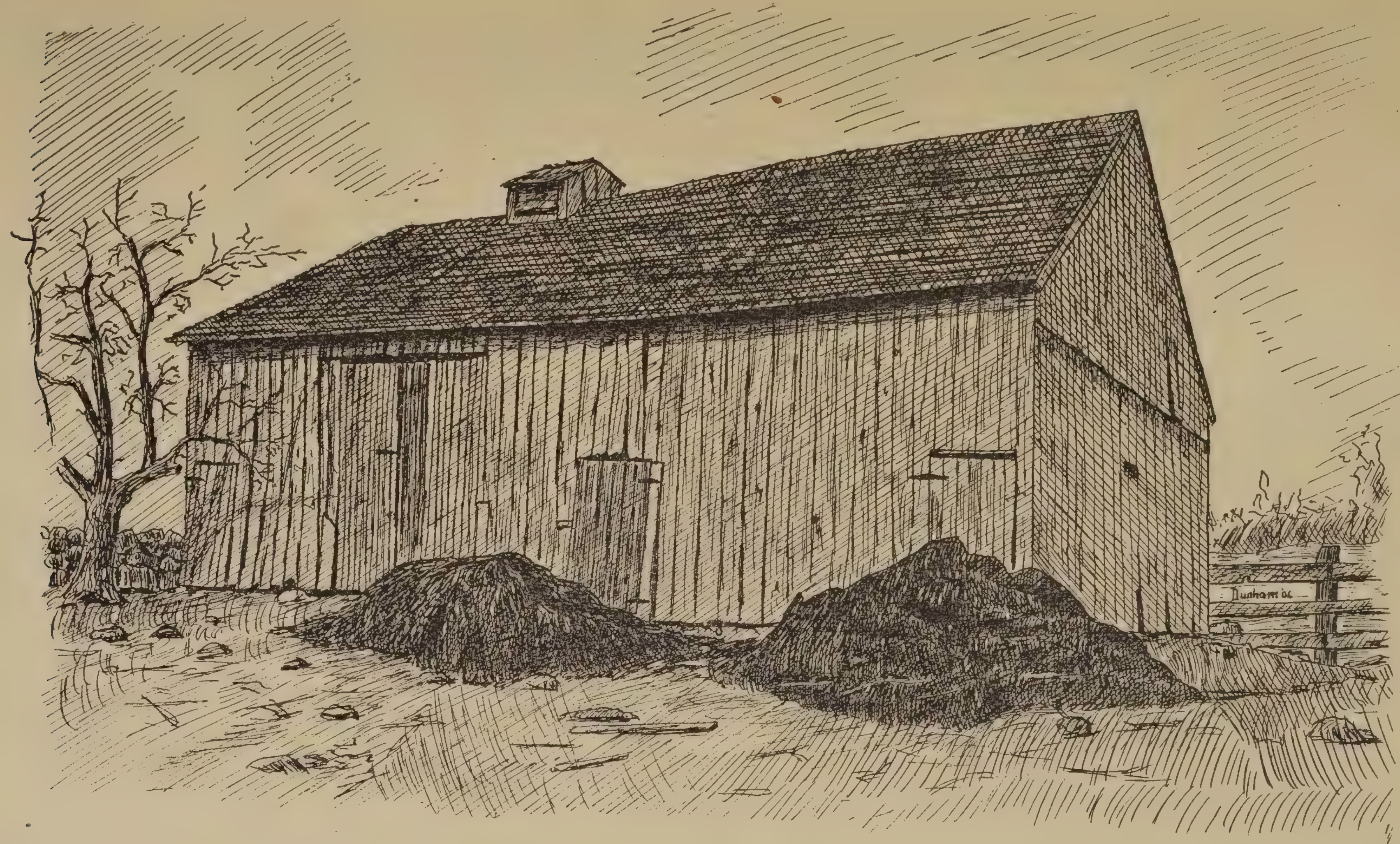


FIG. 30—Drawing made from photograph showing exterior of barn where experiments given in table 21 were made.

comparing the corresponding experiments in Table 21, parts A and B, it will be noticed that in each case there was a very marked reduction in the number of bacteria by the use of the covered pail. While the numbers of bacteria which gained access to the covered pail are very much higher than in the preceding experiments the relative difference between the germ content of the milk from the open and the covered pails is even greater than in the preceding experiments. It is evident that the conditions were for some reason considerably

Table 21.

Effect of covered pail in stable where but little care is given to cleanliness.

A. Open Pail.

Number of Experiment	Total Bacteria	Acid Bacteria	Liquefying Bacteria
Number 1	811,900	761,660	23,790
Number 2	9,100,000	9,087,900	4,160
Number 3	3,113,000	2,025,000	26,660
Number 4	3,025,000	314,600	30,000
Number 5	4,470,000	2,443,000	26,660
Number 6	115,400	21,040	10,000
Average	3,439,200	2,442,200	18,550

B. Pail with Cover.

Number of Experiment	Total Bacteria	Acid Bacteria	Liquefying Bacteria
Number 1	19,790	13,330	0
Number 2	219,160	189,800	0
Number 3	64,580	27,000	14,580
Number 4	90,000	32,000	4,000
Number 5	220,800	81,600	15,830
Number 6	7,250	3,500	166
Average	103,600	57,800	5,760

Average for open pail.

Average for covered pail.

Average difference in favor of covered pail.

FIG. 31—Photograph showing filthy condition of cows where experiments given in table 21 were made.

better on the day the last samples were taken than they had been on the preceding days yet even here the relative difference is very striking. While the samples from the open pail averaged considerably over 3,000,000 bacteria per cubic centimeter the samples from the covered pail averaged but a little over 100,000 or practically 3 per cent. of the number found in the milk from the open pail. This means that over thirty-three times the number of bacteria fell into the milk drawn into the open pail as fell into the milk drawn into the covered pail. The real significance of this is apparent when we remember that the number of bacteria in fresh milk is an indication of the amount of dirt which has gotten into the milk. The diagram given in connection with this table shows in a striking way the relative germ content of these two series of samples. The length of the lines in this diagram indicate the two averages so that the difference in their length represents graphically the difference between 103,000 and 3,439,000 bacteria per cubic centimeter of milk. Comparing the results obtained in these three different barns it is evident that the relative value of the use of the covered pail as a means of excluding dirt and bacterial contamination varies

with the conditions of cleanliness existing in the stable. In the College barn 85 per cent. of the bacteria were excluded in one series and 83 per cent. in the other series by the use of the cover. This represents the value of the pail in the best of the three stables. In the second barn where the actual conditions of the stable and the cows were good but the feeding and brushing at milking time filled the atmosphere with dust, 95 per cent. of the bacteria were excluded by the use of the cover while in the third stable where the conditions were decidedly unsanitary and representative of the worst grade of dairy conditions the use of the cover kept out 97 per cent. of the bacteria which normally fell into the open pail. This series of tests will serve as a fair indication of the value of such a cover for the production of milk relatively free from stable contamination. The relative advantage gained by the use of the cover increases as the unsanitary conditions of the stable increase even though the numbers of bacteria which gain access to the milk drawn into the covered pail in such cases may be many times higher than would be obtained in stables where better conditions existed.

The latest development in the way of covered pails is shown in Fig. 32. Like all the others the effort in this case

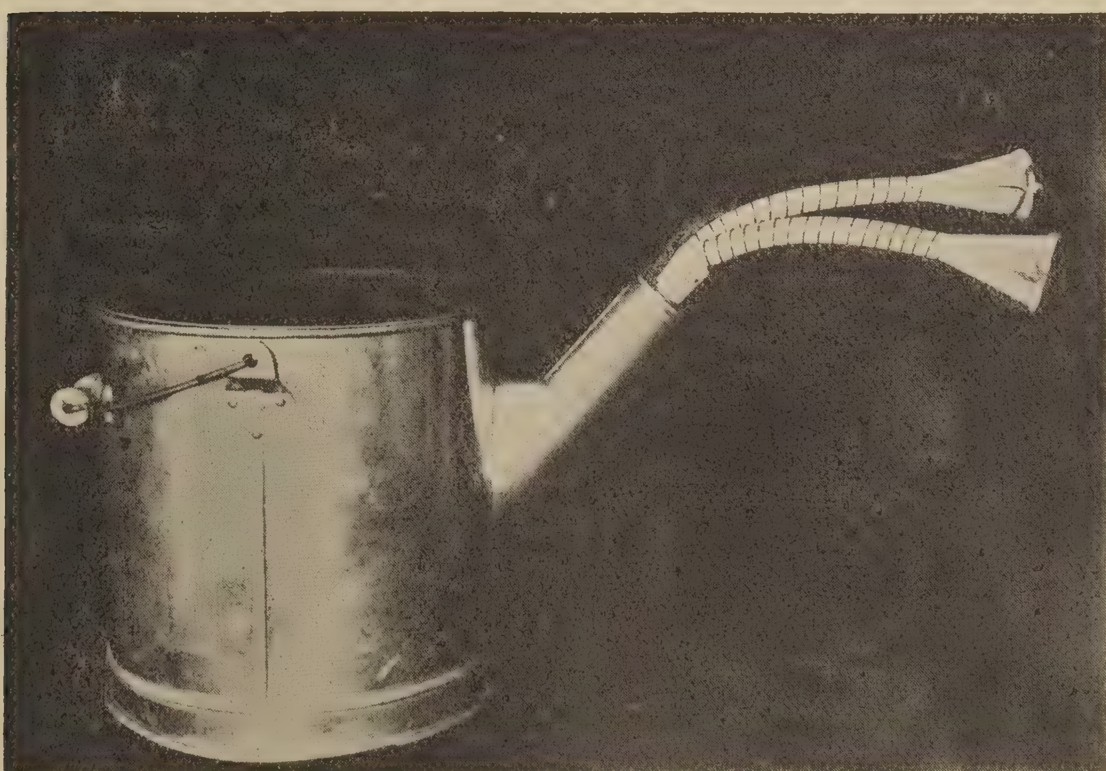


FIG. 32—The latest development in covered milk pails.

is to reduce the amount of external contamination to just as low a point as possible. The pail is intended to be used as a stool by the milker. A spout is attached to one side of the pail to the top of which two rubber tubes are attached each tube having a funnel shaped enlargement at the upper end, about 1½ inches by 2 inches across at the top. These funnels are attached to the hands of the milker by elastic bands so that each funnel is held directly under the end of the teat from which the milk is being drawn. This device reduces the area in which dirt can get into the milk to a very small space and a few preliminary tests indicate that the device is very effective in excluding bacteria from the milk.* It is somewhat inconvenient, however, to hold the rubber tubes attached to the hands during the process of milking and it is doubtful if this device in its present form would prove to be practical for milking any number of cows. It might, however, prove very satisfactory for milking one or two cows where a specially fine quality of milk is desired for home consumption. This pail is still in the experimental stage and it is possible that the inventor may make such changes as to make it a practical pail of high efficiency for general use. This pail is at least of more than passing interest as illustrating the effort being put forth to produce a device which shall be as effective as possible in the production of milk free from external dirt and bacterial contamination.

VALUE OF A STRAINER USED WITH COVERED PAILS.

The notion that all milk should be strained after it is drawn from the cow is deeply seated in the minds of all dairymen. This practice is useful as a means of removing a portion of the dirt from milk produced under average conditions in the ordinary way. Dairymen consider this practice so essential that it is only natural that when covered pails came into use it was considered necessary to have some sort of a straining device on the pail so that the milk would be strained as it entered the pail. As a result of this belief that milk must be strained we find all of the early covered pails equipped with some sort of a strainer, usually either cloth or absorbent cotton and in some cases both. Certain experiments made by the writer have shown that it is not always desirable to strain milk and, in fact, it may be detrimental to

*It has been necessary for the writer to report this work sooner than would be desirable in order to close up his work in connection with the Station before assuming his duties in his new position at Cornell University.

the quality of the milk to pass it through a strainer. This is true of the milk produced under highly sanitary conditions where but little external contamination gets into the milk. Straining milk of this sort through a cloth strainer normally lessens its keeping quality. In this way the value of the milk may be actually injured by the straining process. This being the case it is evidently undesirable to pass milk through a strainer if it has been produced under such good conditions that there is no insoluble dirt which can be strained out. With this fact in mind it was thought desirable to make tests with the different covered pails to determine whether or not the use of a strainer was desirable. Such tests have been made with several of the more important pails now in use.

THE STADTMUELLER COVERED PAIL WITH AND WITHOUT STRAINER.

A series of tests to determine the effect of using a strainer upon the Stadtmueller pail has been made and the results are

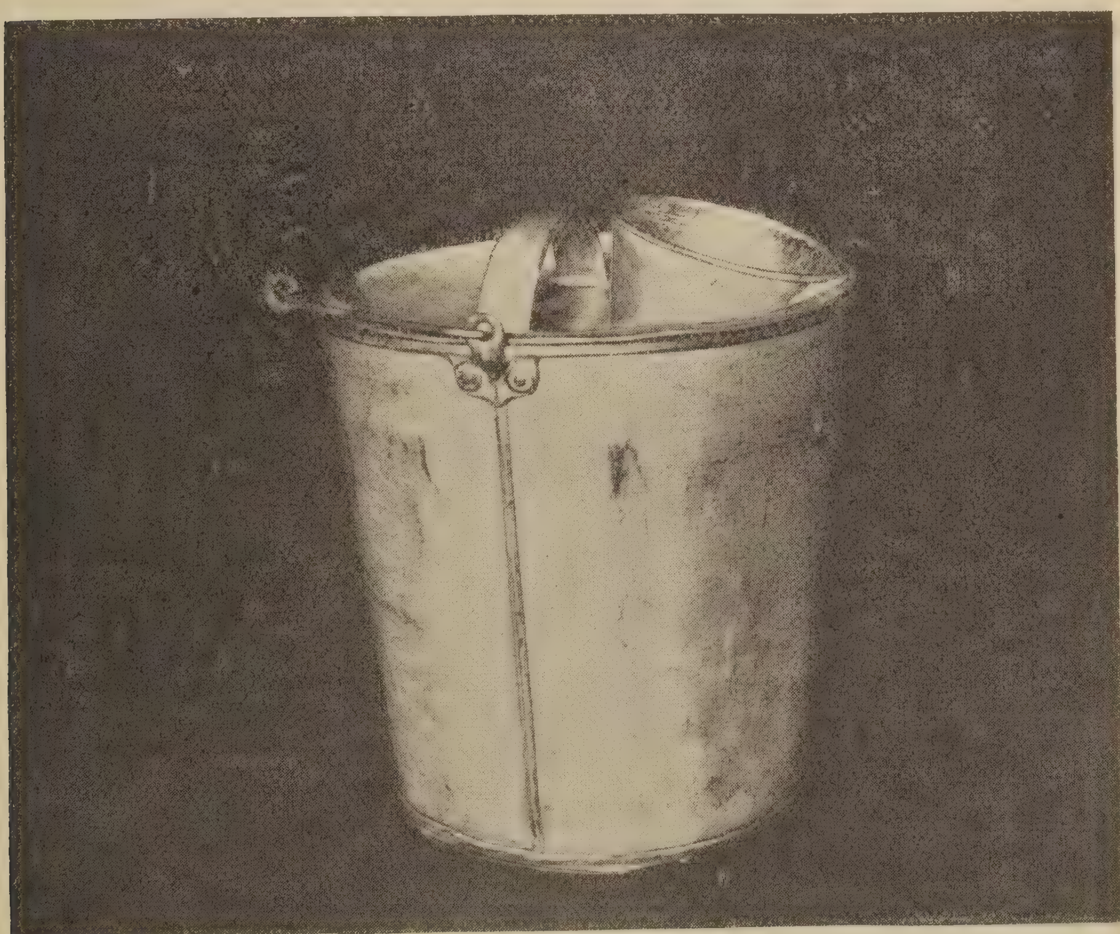


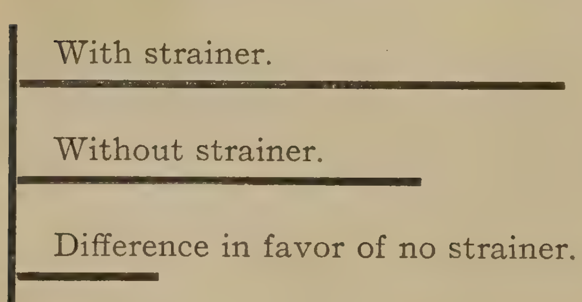
FIG. 33—Photograph showing the Stadtmueller covered pail without strainer. Compare with Fig. 27.

given in Table 22. A photograph of this pail without the strainer attachment is shown in Fig. 33. This reduces the cover attachment to a simple tin cover carrying an open funnel four inches in diameter. The strainer ordinarily used with this pail consists of two thicknesses of fine cheese cloth supported by fine copper gauze and this arrangement was used in these experiments. The pail equipped with the strainer attachment is shown in Fig. 27.

Table 22.

Stadtmueller Covered Pail with and without strainer (wire gauze and two thicknesses of fine cheese cloth).

Date	Kind of pail used	Total Bacteria	Acid Bacteria	Liquefying Bacteria
March 28....	With strainer	1,300	130	67
" 28....	Without strainer	450	90	0
" 28....	With strainer	840	208	8
" 28....	Without strainer	800	167	0
" 29....	With strainer	940	300	50
" 29....	Without strainer	567	50	40
" 29....	With strainer	2,050	590	130
" 29....	Without strainer	1,500	290	100
" 30....	With strainer	1,340	150	66
" 30....	Without strainer	1,658	125	0
" 30....	With strainer	2,520	230	60
" 30....	Without strainer	1,700	475	108
" 31....	With strainer	1,150	367	17
" 31....	Without strainer	500	117	0
" 31....	With strainer	1,350	417	8
" 31....	Without strainer	658	225	50
April 11....	With strainer	1,400	196	50
" 11....	Without strainer	525	100	0
" 11....	With strainer	640	146	17
" 11....	Without strainer	660	200	13
" 12....	With strainer	360	117	29
" 12....	Without strainer	930	338	67
" 12....	With strainer	610	87	113
" 12....	Without strainer	770	270	46
Average...	With strainer	1,210	240	52
Average...	Without strainer	890	204	36



The milk from which these tests were made was obtained by milking one group of five cows into the pail with the strainer attachment and another group of five cows into a similar pail from which the strainer device had been removed. Samples were then taken from the mixed milk of these two groups of cows and bacteriological determinations made as already described earlier in this bulletin.

A study of Table 22 shows rather striking results in the germ content of the milk drawn into the pail with and without the strainer. In the first place it may be noticed that in eight of the experiments out of the twelve milk drawn through the strainer showed a higher germ content than the milk drawn at the same milking into the pail which had no strainer. In four of the experiments the results show a smaller germ content in the milk which passed through the strainer. The averages for these two series of experiments indicate a decided advantage in favor of using the pail without the strainer. These average differences are strikingly illustrated by the diagram which is given in connection with Table 22. The milk drawn into the pail without the strainer contained on an average but 73.5 per cent. of the number of bacteria which were found in the milk drawn into the pail which bore the strainer. These results indicate that better results can usually be obtained by using the pail without the strainer cloth. The larger germ content normally found in the milk drawn through the strainer is no doubt due to the fact that whatever dirt falls into the strainer is broken up and driven through into the milk by the succeeding streams of milk beating upon it as it rests on the strainer so that more bacteria actually became disseminated through the milk when the strainer is used than when the strainer is not used under the same stable conditions. It was also found that the milk drawn without the use of the strainer kept longer than that drawn through the strainer. An added advantage in using this pail without the strainer attachment is in its greater simplicity and the avoidance of having the extra parts to be washed each time.

Strainer tests with the North covered pail. This pail fitted ready for use is shown in Fig. 34. The cover consists of a tin cover slightly raised in the center with a circular opening four inches in diameter in the middle. Two layers of fine strainer cloth are laid over the top of the pail and the cover put in place thus holding the strainer cloth in position. The opening in this pail is of practically the same size as that in the Stadtmueller pail.

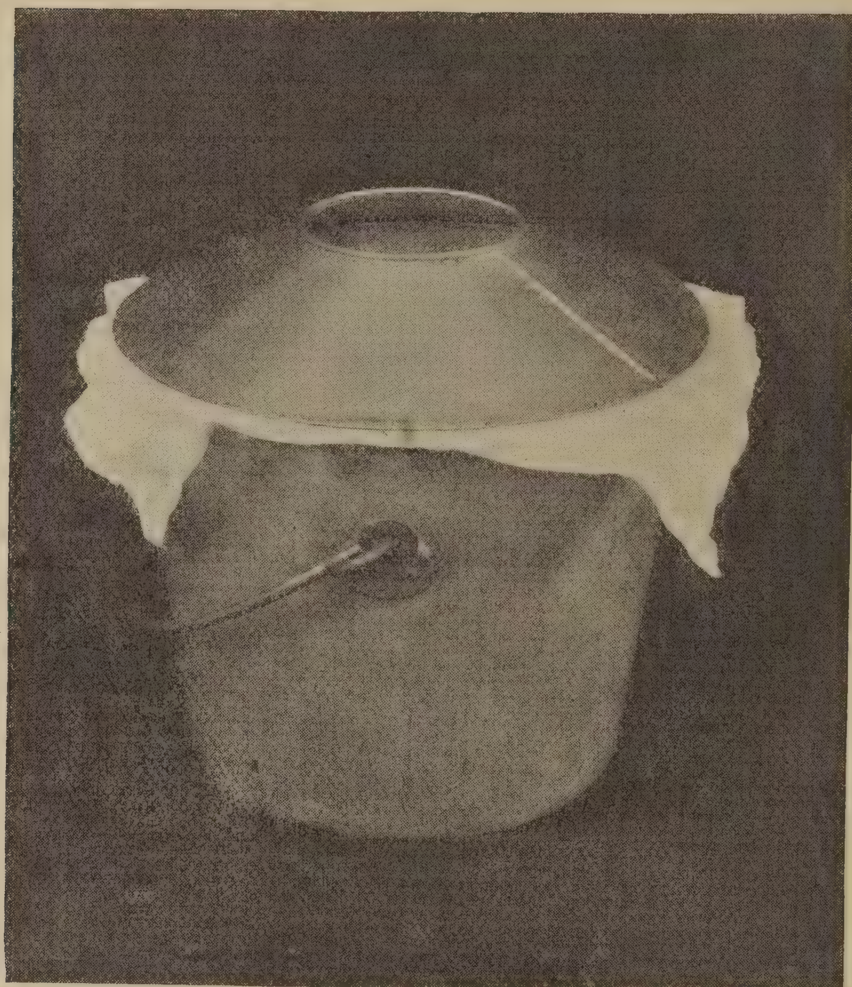


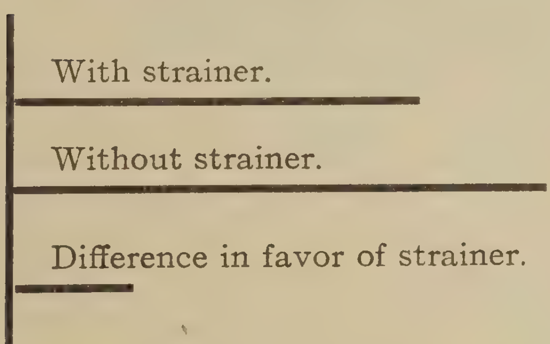
FIG. 34—Photograph of the "North" covered milk pail used in experiments given in table 23.

The series of experiments given in Table 23 show the results obtained by using the pail with and without the strainer cloth. The samples were obtained in the same manner as those for the preceding series of tests, that is, samples were taken from the mixed milk of two lots of five cows each, the two groups being alternated from day to day in order to avoid any difference due to the bacterial content of the milk of the different cows. In this series of experiments half of the individual tests are in favor of using the strainer cloth while the other half are in favor of omitting the cloth from the pail. While there is apparently no difference in favor of either method as shown by the relative numbers of bacteria in the individual tests there is on the whole a difference in favor of using the strainer as shown by the averages for the two series of samples. The milk drawn into the pail with the strainer contained an average of 890 bacteria or 77 per cent.

Table 23.

North Pail with and without strainer (two thicknesses of fine cheese cloth).

Date	Time	Kind of pail	Total Bacteria	Acid Bacteria	Liq'fying Bactiria
April 27....	A. M.	With strainer	215	20	92
" 27....	A. M.	Without strainer	170	30	0
" 27....	P. M.	With strainer	646	96	37
" 27....	P. M.	Without strainer	825	208	4
" 28....	A. M.	With strainer	1,245	390	120
" 28....	A. M.	Without strainer	2,460	430	104
" 28....	P. M.	With strainer	1,100	125	60
" 28....	P. M.	Without strainer	2,050	70	608
" 29....	A. M.	With strainer	938	350	54
" 29....	A. M.	Without strainer	1,654	200	596
" 29....	P. M.	With strainer	696	35	200
" 29....	P. M.	Without strainer	1,258	410	21
" 30....	A. M.	With strainer	1,350	310	207
" 30....	A. M.	Without strainer	900	255	13
" 30....	P. M.	With strainer	1,606	263	44
" 30....	P. M.	Without strainer	1,555	255	120
May 2....	A. M.	With strainer	227	8	8
" 2....	A. M.	Without strainer	140	40	0
" 2....	P. M.	With strainer	950	292	15
" 2....	P. M.	Without strainer	730	142	25
Average..		With strainer	890	180	85
Average..		Without strainer	1,160	200	150



of the average number found in the milk drawn into the pail where the strainer cloth was not used. These results would indicate some advantage in the use of the strainer though it is not indicated in all of the experiments. This pail has one advantage over the Stadtmueller pail when used with the strainer in the fact that any dirt falling into the opening naturally works down toward the lower edge of the pail so that the succeeding streams of milk do not strike upon it breaking it to pieces and driving it through the strainer. It has the practical disadvantage, however, that the pail is not quite as easy to milk into as the Stadtmueller pail because the

opening is in the center of the cover and it is necessary to hold the pail further under the cow thus making it necessary for the milker to sit closer to the cow while he is milking. This pail is being used with excellent results as shown by the bacteria counts given on page 170 of the 1905 Report of this Station.

FIG. 35—Gurler covered pail equipped with absorbent cotton strainer ready for use.

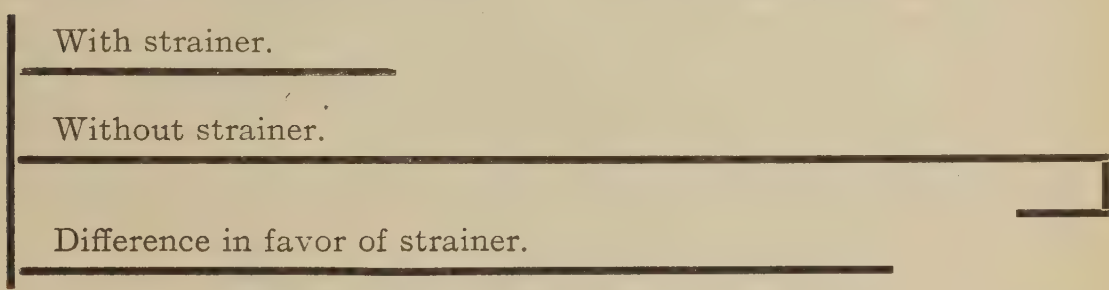
Strainer tests with the Gurler covered pail. This is the well known pail used by Mr. H. B. Gurler of De Kolb, Illinois. The pail ready for use is illustrated in Fig. 35 while the separate parts are shown in Fig. 36. The strainer used on this pail consists of a layer of absorbent cotton placed between two thicknesses of cheese cloth. This strainer is then laid over the top of the pail and the loose cover placed down upon it thus holding it in position. The pail is provided with a spout upon one side making it unnecessary to remove the cover when pouring the milk from the pail. A series of tests to determine the efficiency of this form of strainer has been made and the results are given in Table 24.

The samples were obtained by taking the mixed milk from two lots of five cows as already described for the previous experiments. In four of the six experiments made, the milk

Table 24.

Gurler Pail with and without cotton and cheese cloth strainer.

Date	Kind of pail	Total Bacteria	Acid Bacteria	Liquefying Bacteria
April 5......	With strainer	508	96	25
" 5......	Without strainer	9,533	8,158	33
" 5......	With strainer	775	50	8
" 5......	Without strainer	738	113	38
" 6......	With strainer	417	104	4
" 6......	Without strainer	1,563	446	404
" 6......	With strainer	1,021	158	46
" 6......	Without strainer	783	79	8
" 8......	With strainer	1,065	530	25
" 8......	Without strainer	1,533	929	4
" 8......	With strainer	1,158	513	21
" 8......	Without strainer	2,500	1,258	33
Average...	With strainer	824	242	22
Average...	Without strainer	2,775	1,830	87



drawn through the strainer contained a decidedly lower germ content than did the corresponding sample drawn into the pail without the strainer. In one case the two samples contained practically the same number of bacteria, the number in each case being very small while in one experiment decidedly more bacteria were found in the milk drawn through the strainer than were found in the milk drawn without the strainer. In the majority of the tests the difference in the germ content is decidedly in favor of the milk which passed through the strainer on its way into the pail. The average for the series of tests including those where the germ content was against the use of the strainer is 824 bacteria per cubic centimeter or 30 per cent. of the number found in the milk drawn without the strainer. This is, of course, a decided difference in favor of the use of this form of strainer arrangement. The results obtained here are what might be expected since it is always difficult for bacteria to pass through a layer of absorbent cotton. It is evident that many bacteria are held by the cotton in this strainer and are therefore excluded from the milk. The very low number of bacteria found in the milk in some

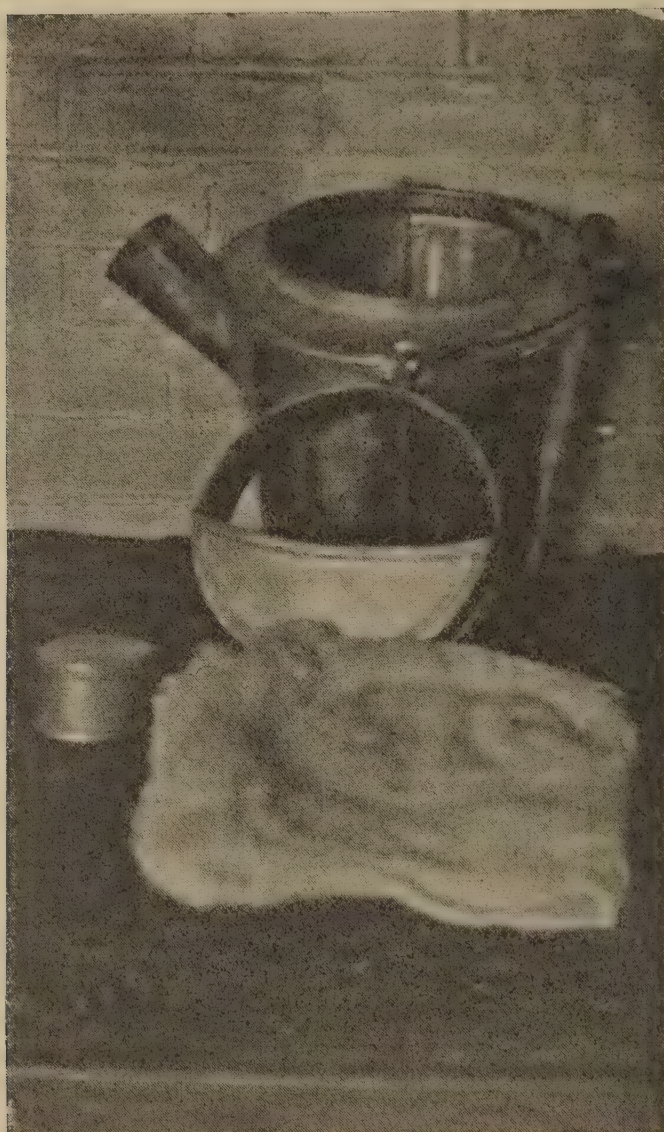


FIG. 36—Separate parts of Gurler covered pail.

of these tests is very striking and is an indication of what it is possible to do in a stable where there are no extreme efforts made to maintain a high degree of cleanliness. There is, of course, a slight economic disadvantage in the use of this pail in that the absorbent cotton is somewhat expensive and its use adds very slightly to the cost of production. However, this increased cost is quite insignificant when considered on the basis of the increased cost per quart of milk.

Strainer tests with the Haymaker pail. A few tests made with this pail with and without the cover have been given in the early part of this article. This pail as sent out by the inventor has a very ingenious arrangement for straining the milk. This strainer consists of a small cistern with a wide flange over which a strainer cloth is placed and held in posi-

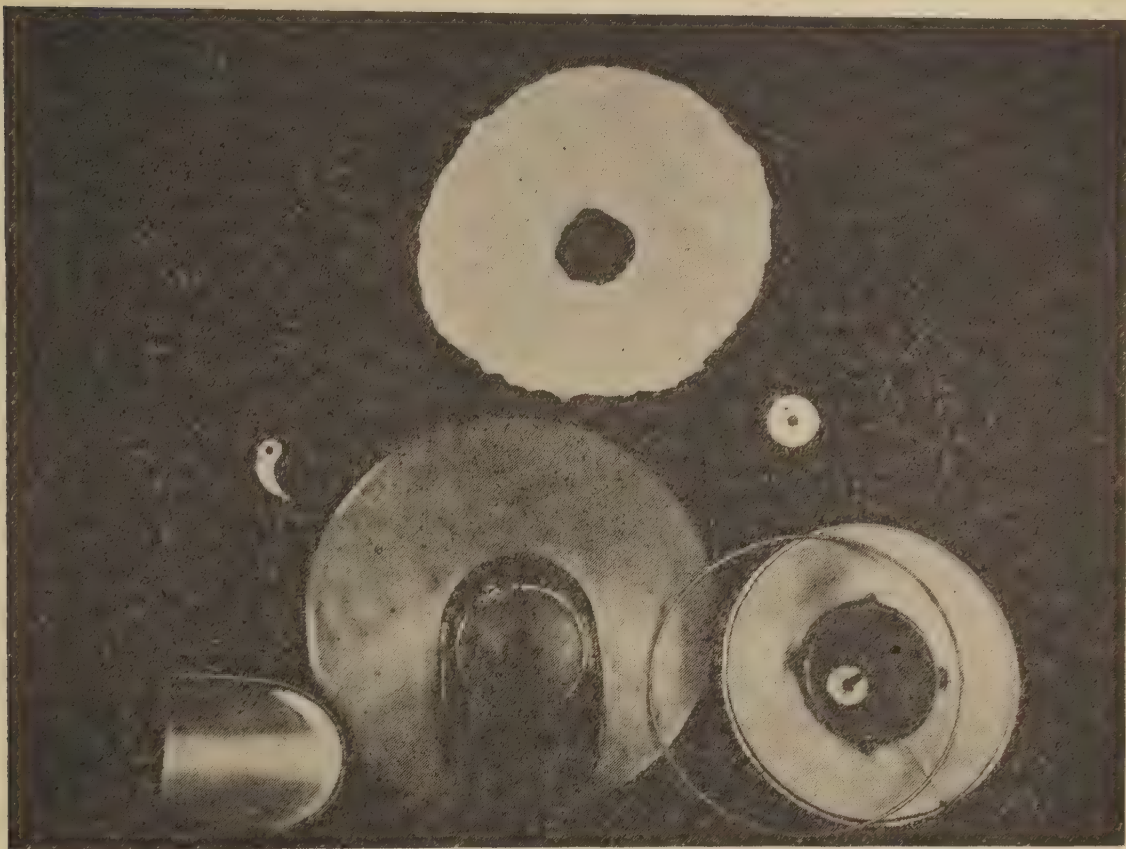


FIG. 37—Photograph showing separate parts of cover and strainer device of the Haymaker pail.

tion by a wire hoop, the entire strainer attachment being secured to the under side of the cover by means of a small key. The separate parts of this strainer and cover are shown by the photograph in Fig. 37. The small cistern comes directly under the opening of the funnel on top of the cover so that the milk as it enters the pail falls directly into this cistern without passing through the strainer cloth. As soon as this cistern is filled the milk is strained *upward* through the cloth, dripping over the edge and falling into the pail proper. The purpose of this device is to avoid the disadvantage of some other pails where any dirt falling into the opening is held where succeeding streams of milk beat it to pieces and wash it through into the milk. In this pail the milk enters the small cistern where the following jets of milk cannot strike it and thus gives an opportunity for any dirt to settle in the bottom and it is, therefore, not driven through into the pail. Owing to circumstances* it has been possible to make only a few tests with this strainer device. The results of these trials are given in Table 25.

*See note at bottom of page 92.

Table 25.

Haymaker Pail with and without strainer attachment.

Date	Kind of pail	Total Bacteria	Acid Bacteria	Liquefying Bacteria
Feb. 28....	With strainer	1,283	500	67
Feb. 28....	Without strainer	425	108	8
March 1....	With strainer	3,230	2,625	34
" 1....	Without strainer	4,230	3,225	33
" 5....	With strainer	550	230	33
" 5....	Without strainer	830	50	92
July 12....	With strainer	940	730	0
" 12....	Without strainer	560	110	50
" 13....	With strainer	183	50	0
" 13....	Without strainer	3,100	342	0
Average...	With strainer	1,237	827	27
Average...	Without strainer	1,829	767	37

It will be seen that out of the five trials made three of the samples obtained with the strainer contained a smaller germ content than did those obtained without the strainer, while in the other two experiments the difference was in favor of not using the strainer device. The averages for the two series show a difference in favor of using the strainer. This difference is, however, not relatively very great. As an offset to this advantage in using the cover as shown in the decreased germ content must be placed the inconvenience in the use of the strainer device. The extra number of pieces necessary to be washed each time in connection with this strainer is a disadvantage. There is also a small amount of milk left in the cistern which must be discarded. But the greatest drawback to the use of this strainer attachment lies in the fact that the milk does not strain readily enough to allow it to pass easily into the pail. This often results in the funnel on top of the pail becoming full of milk and running over during the process of milking. This fact practically excludes the use of this device in its present form as a practical means for reducing the germ content of the milk. It may be possible to change this arrangement so that it would do away with this objection but in its present form it is not practical, especially while there are other pails more simple in arrangement which give equally good results. This pail might, however, prove very satisfactory when used without this inner strainer device. In fact in this form it is a very easy pail to milk into and the area through which dirt can fall into the pail is greatly reduced.

SUMMARY.

The experiments given on the preceding pages seem to warrant the following conclusions:

1. The use of the covered milk pail is of great advantage in any stable in excluding dirt and bacteria from the milk. The relative advantage gained by the use of the cover depends upon the sanitary condition of the stable.

2. The special form of cover does not seem to be important provided it is a device practical for use and the area through which dirt can gain access to the milk is reduced as much as possible.

3. Whether or not a strainer on the covered pail is desirable depends upon the style of the straining device.

4. The use of the strainer in a pail where the dirt which falls into the opening is likely to be driven through by the succeeding streams of milk is not desirable. Its use tends to increase the germ content of the milk and injure its keeping quality.

5. In pails where the dirt which falls in does not remain where the succeeding streams strike against it a strainer cloth aids in keeping down the number of bacteria which gain access to the milk. The North pail is an illustration of this type.

6. The use of absorbent cotton as a strainer as in the Gurler pail is a decided advantage in preventing the entrance of bacteria into the milk.

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BULLETIN No. 47, JUNE, 1907.

MILKING MACHINES.

Part I. Effect Upon Quality of Milk.

BY W. A. STOCKING, JR., AND C. J. MASON.

Part II. Effect Upon Milk Yield.

BY C. L. BEACH.

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MILKING MACHINES.*

PART I. EFFECT UPON QUALITY OF MILK.

BY W. A. STOCKING, JR., AND C. J. MASON.

INTRODUCTION.

The labor connected with the routine work of milking is one of the most exacting operations on the ordinary dairy farm. The operation must be performed regularly twice each day since it will not do to have the periods between milkings materially different in length. The cows must be milked weekdays and Sundays and the milking must be done three hundred sixty-five days in the year. The labor cost of milking is considerable, much more than the ordinary dairyman realizes if he has not carefully figured up the actual cost in time required to milk a cow for a year. In order to get the best results, each cow should be milked regularly by the same milker. She should be treated kindly and milked out as clean as possible. With the present difficulty of securing competent farm help, it is frequently difficult and in many cases impossible, to secure satisfactory milkers. In many cases it is necessary to keep more help than would otherwise be needed in order to have men available at milking time. Frequently the number of cows which a dairyman can keep is limited by the number of milkers which he is able to obtain. Not infrequently a dairyman finds himself with insufficient help for milking his herd, and occasionally a man gives up the dairy business simply because of the impossibility of getting satisfactory help at prices warranted by the returns from the business.

Manual labor is one of the most expensive things which the farmer has to buy, and wherever possible, he makes use of machinery in doing his work. In this way he lessens the number of men he has to employ. During the past few years many of the common farm operations have been made easier and very much cheaper because of the improved machinery which has been developed for agricultural purposes. If the milking could also be done by machinery, the work would be made very much easier and the cost of the operation might be very ma-

*The machine used in all the experiments discussed in this bulletin was the Burrell-Lawrence-Kennedy milking machine.

terially reduced. This operation, however, seems to have baffled agricultural inventors. The nervous, sensitive disposition of the individual cows, together with the lack of uniformity in the form and size of the udder and teats, has made it very difficult to invent a machine which would milk different cows satisfactorily.

Aside from the mere matter of reliability and expense, the problem of getting satisfactory milkers is a difficult one. The demand is steadily increasing for milk which has been produced under such conditions that it shall be clean and wholesome when it reaches the consumer. It is now a generally recognized fact that much of the milk which is sent to our cities is not as clean and wholesome as it should be. Health officers and the public generally are insisting upon an improvement of the sanitary conditions under which milk is produced and handled. Perhaps no food product is more easily contaminated and injured by unsanitary conditions, than milk. If the stables and the cows are not properly cared for, and if the proper care and cleanliness is not exercised in the milking and subsequent handling, the milk may easily become contaminated with dirt and various forms of bacteria.

It is difficult to make the ordinary farm help appreciate the necessity for extreme cleanliness in connection with milking and the subsequent handling of the product. In fact, it is frequently impossible to get help which will exercise the proper care for the production of clean milk. This fact, together with the cost of milking, has greatly stimulated the inventors of the various forms of milking machines, which have given more or less promise of success during the past few years. In order that milk shall be of the greatest value, it should reach the consumer in as nearly as possible the condition in which it is drawn from the normal udder of the healthy cow. Much of the dirt and bacterial contamination which affects the quality of the milk, gains entrance to it during the process of milking and before the milk leaves the stable. In many cases covered milk pails are used as a means of reducing this stable contamination. But if the milking could be done by means of a machine so that the milk would pass directly from the udder into a covered pail, thus excluding all chance for the entrance of dust and bacteria and the absorption of odors from the stable, the quality of the milk would be materially improved.

Several milking machines have appeared on the market, but these have not proved to be satisfactory in all respects, and their use has not become general. Recently, however, a machine which gives promise of success, has been developed, and

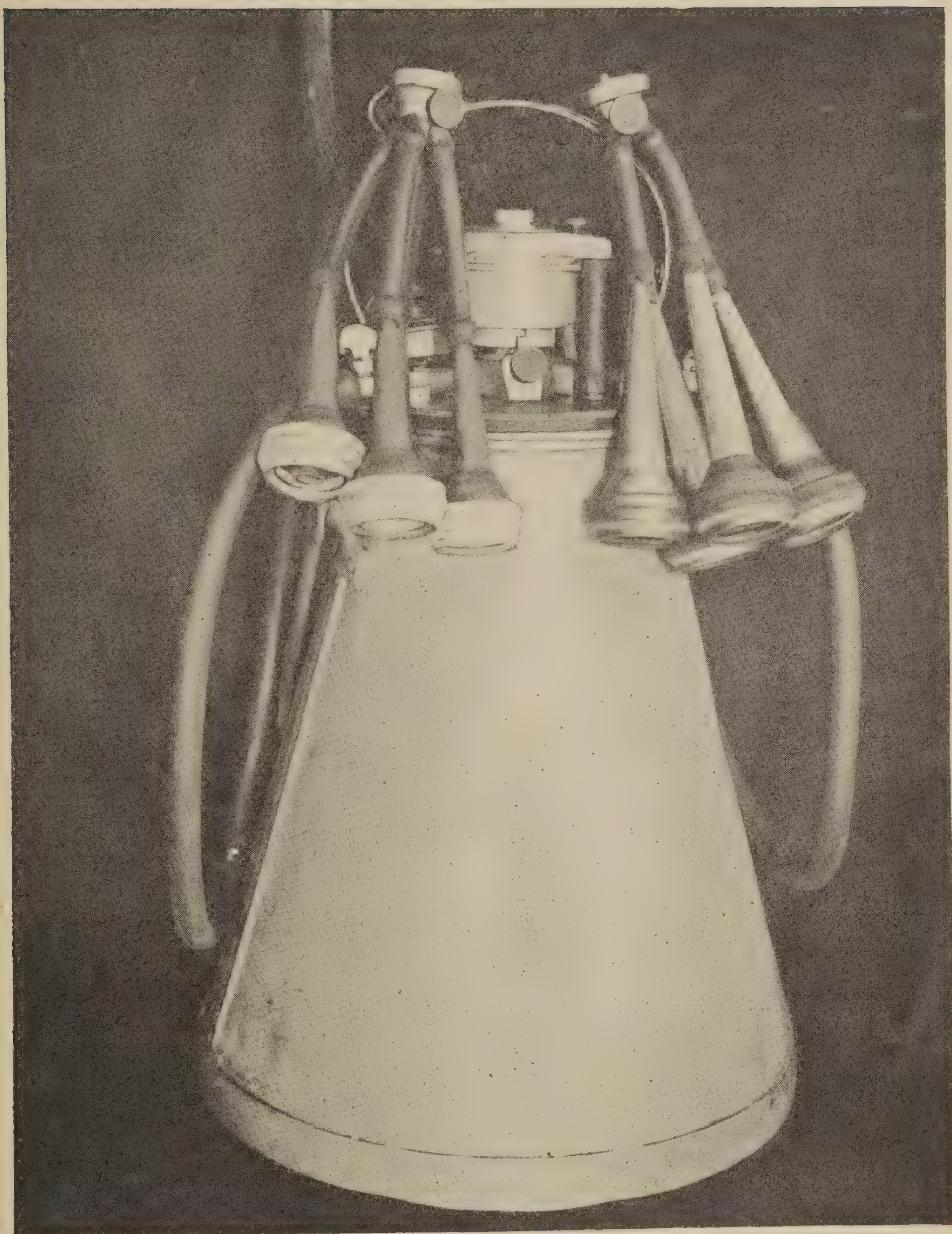

FIG. 38—A nearby view of a machine ready for use.

the results given in the following pages are based upon experiments made with this machine, known as the Burrell-Lawrence-Kennedy cow milker.*

*It is through the generosity and co-operation of D. H. Burrell & Company, Little Falls, New York, who loaned us the machines with which this work was commenced, that it has been possible for the Station to carry on this investigation.

PURPOSE OF THESE EXPERIMENTS.

The work with the milking machines conducted at this Station has been divided into two parts, the problems relating to yield and percentage of butter fat, together with the effect of the machines upon the cows, has been under the direction of Professor C. L. Beach, whose report is given in this bulletin. The problems bearing upon the sanitary conditions of the milk, including methods for cleansing and sterilizing the machines, have been under the direction of the writer.

The purpose of the work in connection with the sanitary features of the machines, has been to determine the effect upon the germ content of the milk drawn by the machine compared with milk drawn by hand under the same conditions. At the same time, a study of the care necessary to keep the machines clean and in sterile condition has been made.

METHOD OF EXPERIMENTS.

The machines were first installed at the College barn in October, 1905, and have been used continuously ever since that date. At first only a few cows were milked by the machines. In order to determine the effect of the machines upon the germ content of the milk, samples were taken from the milk of an equal number of cows, one group being milked by the machine and the other by hand at the same milking. The mixed milk from several cows was taken in order to eliminate differences due to individual germ content of the different udders. From time to time, the groups of cows were alternated so that those being milked by hand during one period were milked by machines during the next, and those milked by machines in the first period were milked by hand during the second period. From time to time the methods for cleansing and sterilizing the machines were varied in order to determine the amount of care necessary to keep the machines in sanitary condition.

It should be borne in mind that all of these experiments were made in the College barn where the condition of cleanliness is somewhat better than the average, and the machine drawn milk is compared with milk drawn by hand into the Stadtmueller covered pail, so that the machine milk is compared with a grade of hand drawn milk considerably better than would be obtained in the ordinary barn under usual conditions.

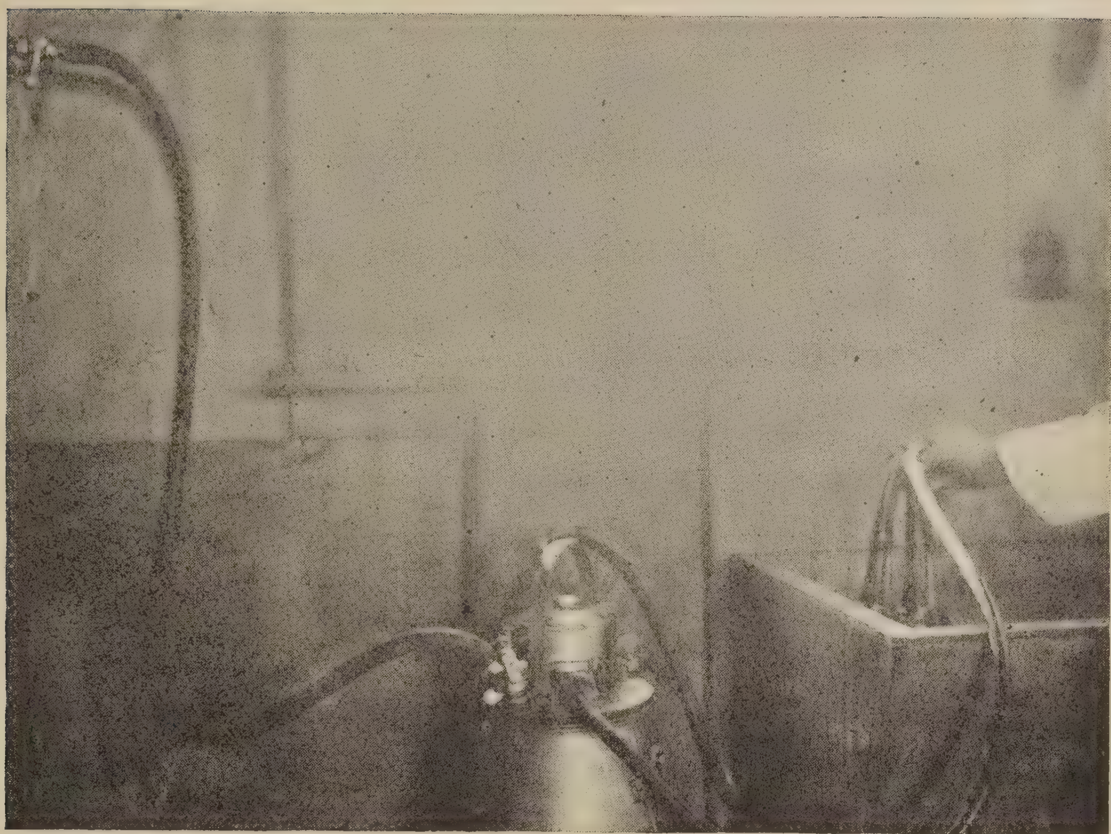

FIG. 39—Showing method of rinsing machine by pumping water through it. See table 26.

FIRST TREATMENT OF THE MACHINES.

At the beginning of these experiments, a test was made to determine the influence upon the germ content of the milk when the machines were washed as the ordinary dairy utensils are frequently cared for on the farm. During this time the machines were simply washed at night by pumping warm water through them. This was done by connecting the machines to the vacuum system near the sink and plunging the teat cups into the water in the sink, which was then drawn through the tubes into the milk pail. After this thorough rinsing, the machines were allowed to stand until the next morning. This method of washing is illustrated in Fig. 39. After the morning milking, the machines were all taken apart, as shown in Fig. 40, and the tubes and teat cups were more thoroughly washed with the aid of a long handled brush. Hot water with washing powder was used, after which the tubes were rinsed with clean water and hung up in the open air until needed for the evening milking.

The pails were sterilized in the steam sterilizer for one

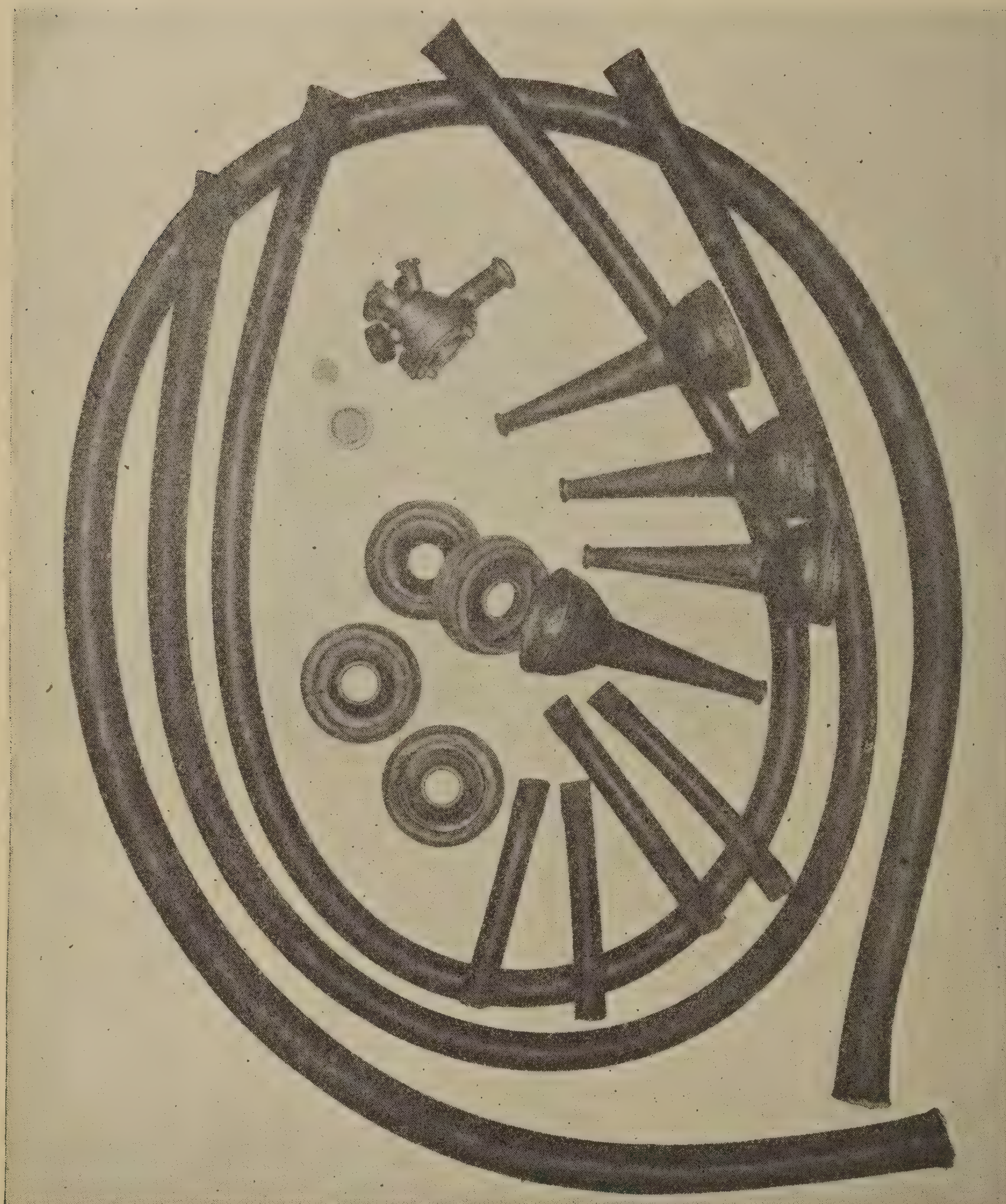

FIG. 40—Showing how the machines may be taken apart for thorough washing.

hour. The comparative germ content of milk drawn through the machines thus treated and milk drawn by hand at the same milking can be seen in Table 26. It will be noted that in every experiment the germ content of the machine drawn milk is higher than in the corresponding hand drawn milk. In some cases the number of bacteria in the hand drawn milk is very small, as in experiments Nos. 254 and 260. In these experiments the germ content of the machine drawn milk is

in itself very good and would make a good showing for the machines were it not for the fact that the numbers in the hand drawn milk are so much smaller. In every case, however, the comparison is in favor of the hand drawn milk and

TABLE 26.

Comparison of hand and machine drawn milk. Machines washed at night by pumping warm water through them, then allowing to stand until morning; after morning milking thoroughly washed with brush and hot water with washing powder; tubes hung up in air; pails sterilized in steam.

Date	Number of Experiment	Method of Milking	Time of Milking	Total Bacteria	Acid Bacteria	Rapid Liquefying Bacteria	Slow Liquefying Bacteria
1905		Machine	P. M.	4,900	*a*	80	290
Nov. 15	239	Hand	P. M.	1,900	*a*	100	260
Nov. 16	241	Machine	A. M.	16,640	*a*	150	1,190
		Hand	A. M.	6,730	*a*	25	2,170
Nov. 16	254	Machine	P. M.	1,660	400	0	70
		Hand	P. M.	200	10	0	10
Nov. 17	256	Machine	A. M.	14,580	5,470	40	1,030
		Hand	A. M.	1,880	430	100	310
Nov. 17	260	Machine	P. M.	2,750	1,530	0	180
		Hand	P. M.	710	175	0	150
Nov. 18	262	Machine	A. M.	35,300	1,120	50	1,770
		Hand	A. M.	3,775	0	0	390
Nov. 19	265	Machine	P. M.	15,430	*a*	0	360
		Hand	P. M.	2,640	*a*	0	180
Nov. 20	267	Machine	A. M.	31,300	*a*	0	1,140
		Hand	A. M.	3,430	*a*	40	260
Nov. 20	269	Machine	P. M.	8,725	1,275	25	390
		Hand	P. M.	1,290	380	0	75
Nov. 21	271	Machine	A. M.	24,000	3,100	40	1,640
		Hand	A. M.	8,890	520	150	1,580
Averages		Machine		15,524	2,149	38	806
		Hand		3,144	1,252	41	538

a = Acid bacteria not determined.

in most cases the difference is very great. As might be expected under such treatment, the machines were not sterile, and it was found that the rubber tubes contained large numbers of bacteria which were not washed out by the method used. It was found under these conditions that the number of bacteria was normally very much higher in the machine drawn milk than in that drawn by hand. The method of washing the machines was therefore changed.

SECOND TREATMENT OF MACHINES.

In Table 27 are given the results of tests where the machines were treated at night as given in connection with Table 26, but after the morning milking, in addition to the previous treatment, the rubber tubes and teat cups were placed in a solution of gold dust, one part (by weight) to three hundred parts of warm water as soon as they were washed, and allowed to remain there until they were needed for the next milking. Just before use, they were thoroughly rinsed with clean water which was nearly free from bacteria.

TABLE 27.

Comparison of hand and machine drawn milk. Night,—same as in Table 26. Morning,—same as in Table 26 except that after tubes and teat cups were washed they were placed in a solution of gold dust 1 part (by weight) to 300 parts of warm water.

Date	Number of Experiment	Method of Milking	Time of Milking	Total Bacteria	Acid Bacteria	Rapid Liquefying Bacteria	Slow Liquefying Bacteria
1905		Machine	P. M.	11,010	1,790	290	1,380
Nov. 21	281	Hand	P. M.	1,760	450	10	380
Nov. 22	283	Machine	A. M.	24,190	3,650	230	2,290
		Hand	A. M.	3,280	575	10	350
Nov. 23	286	Machine	P. M.	27,050	1,130	0	650
		Hand	P. M.	1,225	400	10	410
Nov. 24	288	Machine	A. M.	48,430	6,250	25	2,200
		Hand	A. M.	15,750	2,000	100	450
Nov. 24	290	Machine	P. M.	21,880	660	50	275
		Hand	P. M.	4,400	675	0	525
Nov. 25	292	Machine	A. M.	36,640	3,350	60	900
		Hand	A M.	4,760	725	10	180
Nov. 25	294	Machine	P. M.	14,950	1,400	30	1,092
		Hand	P. M.	1,092	350	10	325
Nov. 26	296	Machine	A. M.	68,530	4,730	1,100	950
		Hand	A. M.	41,500	1,725	40	1,100
Nov. 26	298	Machine	P. M.	106,760	12,630	275	600
		Hand	P. M.	57,030	34,460	40	50
Nov. 27	300	Machine	A. M.	87,960	3,830	940	850
		Hand	A. M.	41,680	2,300	260	100
Nov. 27	303	Machine	P. M.	34,150	6,425	100	40
		Hand	P. M.	33,650	6,700	1,080	1,140
Averages		Machine		43,122	4,167	281	1,020
		Hand		18,729	4,578	142	455

During this series of experiments, the germ content of both

the hand and machine drawn milk runs higher than in the preceding table, but the relation between the two is materially different. In each case the machine drawn milk contained many more bacteria than were found in the milk drawn by hand. It was evident that the treatment was not keeping the machines in a sterile condition. It was found by rinsing the inside of the tubes with 50 cubic centimeters of sterile water after they were removed from the gold dust solution, that large numbers of bacteria were still left in the tubes. In some cases several thousand bacteria per cubic centimeter were found in this rinse water.

THIRD TREATMENT OF THE MACHINES.

When it was found that the gold dust solution was not sufficient to keep the tubes and teat cups sterile, the treatment of the machines was again changed. After washing as previously described, all the rubber tubes and teat cups were placed in a 2½ per cent solution of formalin made from the commercial 40 per cent formalin. The tubes were allowed to lie in this solution between milkings, and were thoroughly rinsed with clean water just before use. In Table 28 are given the results of a series of tests taken when the machines were thus treated. The large tin pail was sterilized by steam, as in the case of the previous experiments. It will be noticed in Table 28 that in many of the experiments the germ content of the machine drawn milk is higher than that drawn by hand at the same milking. In some cases this difference is quite marked in favor of the hand drawn milk. But in some of the experiments, however, the machine drawn milk contained fewer organisms than did that drawn by hand. The average for all of the experiments is somewhat in favor of the machine drawn milk. It was found by testing the tubes with sterile water that the formalin solution was making them practically sterile, there being but few organisms found in them. It was evident from these experiments that the 2½ per cent formalin solution was sufficient to keep the tubes nearly sterile, and it was also found that the solution was beneficial to the texture and keeping quality of the rubber. It was, however, somewhat injurious to the tin covered teat cups, and made them corrode somewhat rapidly. In view of the fact that the use of formalin in connection with milk is prohibited by law in some places and is usually seriously objected to by health officers, it seemed desirable to find some other method for sterilizing the machines without the use of the formalin solution.

FOURTH TREATMENT OF THE MACHINES.

A series of experiments was therefore conducted in which the machines, together with all the rubber parts, were subjected to live steam without pressure for one hour. After this sterilizing in a steam chest, the parts were hung up in the

TABLE 28.

Third treatment of machines. Machines washed as before, pail and cover sterilized in steam. After washing all rubber tubes and teat cups they were placed in a 2½ per cent. solution of formalin till needed for use

Date	Number of Experiment	Method of Milking	Time of Milking	Total Bacteria	Acid Bacteria	Rapid Liquefying Bacteria	Slow Liquefying Bacteria	Hours to Curdling
1905		Machine	P.M.	6,400	1,760	33	790	64*
Dec. 9	316	Hand	P.M.	320	65	0	65	88*
Dec. 10	318	Machine	A.M.	19,300	4,770	92	1,260	64*
		Hand	A.M.	3,875	1,160	0	660	58
Dec. 10	320	Machine	P.M.	38,900	3,015	110	825	64*
		Hand	P.M.	3,490	1,500	15	1,030	64*
Dec. 11	324	Machine	P.M.	8,230	2,100	10	415	79
		Hand	P.M.	2,000	375	0	175	40*
Dec. 18	347	Machine	P.M.	4,400	1,150	0	690	55
		Hand	P.M.	2,540	1,860	0	1,415	64*
Dec. 19	349	Machine	A.M.	16,820	5,760	80	1,100	64*
		Hand	A.M.	16,440	4,040	50	540	51
Dec. 19	356	Machine	P.M.	104,300	4,700	65	13,960	64*
		Hand	P.M.	101,400	1,550	0	515	48
Dec. 20	358	Machine	A.M.	12,230	4,040	185	940	56
		Hand	A.M.	20,500	10,280	140	3,775	48*
Dec. 20	365	Machine	P.M.	2,990	950	85	325	64*
		Hand	P.M.	3,300	880	0	400	80
Dec. 21	370	Machine	P.M.	5,040	1,780	35	530	48
		Hand	P.M.	8,600	6,900	0	215	72
Dec. 22	372	Machine	A.M.	39,360	38,600	5	180	40*
		Hand	A.M.	29,080	7,325	100	2,600	40*
Dec. 22	379	Machine	P.M.	3,520	830	10	650	52
		Hand	P.M.	3,025	570	10	525	103
Dec. 23	381	Machine	A.M.	21,050	5,200	10	1,300	40*
		Hand	A.M.	114,400	79,400	10	860	32
Dec. 23	383	Machine	P.M.	8,500	2,840	0	730	53
		Hand	P.M.	6,420	2,840	0	790	48
Dec. 24	385	Machine	A.M.	10,260	3,320	0	730	40*
		Hand	A.M.	18,150	6,900	0	1,860	64*
Dec. 24	387	Machine	P.M.	2,080	500	10	250	52
		Hand	P.M.	16,400	13,260	125	9,830	64*
Averages		Machine		20,225	5,267	48	1,631	59
		Hand		23,329	9,258	30	1,683	64

*Curdled during the night.

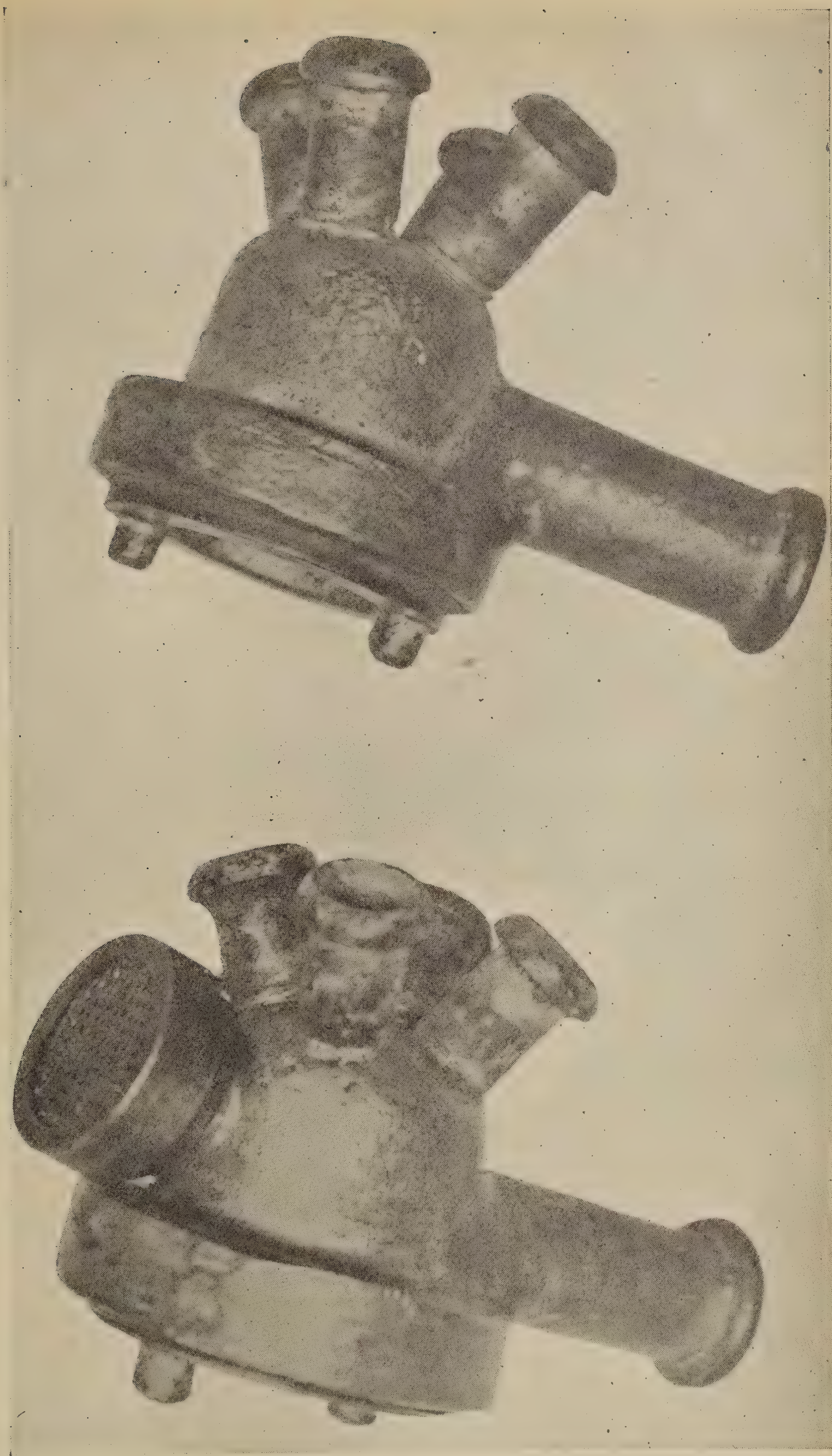

FIG. 41a.—Teat-cup connector without air relief.
b.—Teat-cup connector with air relief.

dairy room until needed. It was found that this treatment killed nearly all of the bacteria in the tubes. Occasionally a few living organisms were found by rinsing the tubes in sterile water just before milking time, but these perhaps were too few to have much effect upon the germ content of the milk. This steam treatment, however, was injurious to the rubber tubes and it was found after a few days sterilizing in this way, that the tubes became so weakened that it was difficult to keep them from dropping apart while they were in use. For this reason the sterilizing in steam does not seem to be satisfactory for the rubber tubes.

But in spite of the fact that the machines were nearly sterile, the machine drawn milk normally contained more bacteria than the corresponding samples drawn by hand. These results may be seen in Table 29. In all of the experiments up to this point, the teat cup connector used was one shown in "a" in Fig. 41.

TABLE 29.

Comparison of hand and machine drawn milk. All parts of machine sterilized in steam (without pressure) for one hour. New style of connectors with air relief used. No cotton filters.

Date	Number of Experiment	Method of Milking	Time of Milking	Total Bacteria	Acid Bacteria	Rapid Liquefying Bacteria	Slow Liquefying Bacteria
1906		Machine	A. M.	22,100	4,170	892	535
Jan. 3	391	Hand	A. M.	52,400	8,250	650	6,850
Jan. 3	396	Machine	P. M.	11,150	2,325	180	1,600
		Hand	P. M.	6,060	1,880	15	350
Jan. 4	398	Machine	A. M.	27,990	9,140	150	2,715
		Hand	A. M.	13,710	5,850	1,375	580
Jan. 4	404	Machine	P. M.	15,660	4,760	360	275
		Hand	P. M.	5,300	2,930	100	415
Jan. 5	406	Machine	A. M.	43,450	17,300	165	2,190
		Hand	A. M.	28,125	11,050	500	1,525
Jan. 5	416	Machine	P. M.	9,560	1,480	540	940
		Hand	P. M.	3,440	1,490	25	350
Averages		Machine		19,984	6,529	381	1,375
		Hand		18,172	5,241	444	1,678

At this point a new style of connector (see "b" in Fig. 41) relief attachment was used. This allowed the air to rush in and relieve the suction in the teat cups and at the same

time largely prevented the surging of the milk back and forth in the long rubber tube. It was thought that possibly the surging of the milk in these tubes had something to do with the higher germ content by breaking up the groups or clusters of the bacteria which were drawn from the udder. It will be seen by a study of Table 29 that this change of connectors

TABLE 30.

After washing all rubber parts and teat cups placed in 10 per cent. salt solution between milkings, both day and night.

Date	Number of Experiment	Method of Milking	Time of Milking	Total Bacteria	Acid Bacteria	Rapid Liquefying Bacteria	Slow Liquefying Bacteria
Jan. 6	418	Machine	A. M.	40,720	11,000	370	1,470
		Hand	A. M.	30,200	19,960	330	1,540
Jan. 7	420	Machine	P. M.	12,125	2,960	3,225	50
		Hand	P. M.	18,775	13,600	75	460
Jan. 8	422	Machine	A. M.	19,600	5,000	3,465	0
		Hand	A. M.	13,600	5,000	125	930
Jan. 8	427	Machine	P. M.	3,120	550	430	80
		Hand	P. M.	6,430	3,940	150	700
Jan. 9	429	Machine	A. M.	22,400	5,600	110	130
		Hand	A. M.	9,230	4,200	65	590
Jan. 9	435	Machine	P. M.	2,630	750	160	160
		Hand	P. M.	3,925	1,092	75	80
Jan. 10	437	Machine	A. M.	12,200	3,730	900	215
		Hand	A. M.	8,970	2,925	15	275
Jan. 10	439	Machine	P. M.	6,920	2,620	60	240
		Hand	P. M.	3,870	1,425	30	325
Jan. 11	441	Machine	A. M.	12,800	1,650	5,300	150
		Hand	A. M.	7,590	2,350	40	230
Jan. 11	443	Machine	P. M.	4,890	1,070	1,460	0
		Hand	P. M.	5,820	2,810	0	110
Jan. 11	454	Machine	P. M.	4,540	980	1,600	0
		Hand	P. M.	12,400	5,290	60	530
Jan. 13	456	Machine	A. M.	13,600	2,000	3,600	0
		Hand	A. M.	2,870	690	10	80
Averages		Machine		12,962	3,159	1,723	208
		Hand		10,306	5,273	81	487

did not produce the desired reduction in germ content for in all but one experiment the machine milk contained larger numbers of bacteria than did the hand drawn milk at the same milking even when the new style of connector with air intake was used.

FIFTH TREATMENT OF THE MACHINES.

The manufacturers of these machines have recommended the use of strong brine as a means of keeping the rubber tubes sweet and free from bacteria between milking times. During the experiments given in Table 30, the machines were washed and the pails steam sterilized as before. But all the rubber tubes and the teat cups were allowed to lie in a 10 per cent salt solution between milkings both day and night.

By testing the rubber tubes thus treated, it was found that the salt solution was not keeping them free from bacteria.

FIG. 42a—Plates showing numbers of bacteria in water used for rinsing inside of rubber tubes which were treated with brine solution. .1 cc. and .5 cc. of rinse water used in plates. Large white spots are liquefied areas. Each black spot is a colony of bacteria. Large black spots are molds.

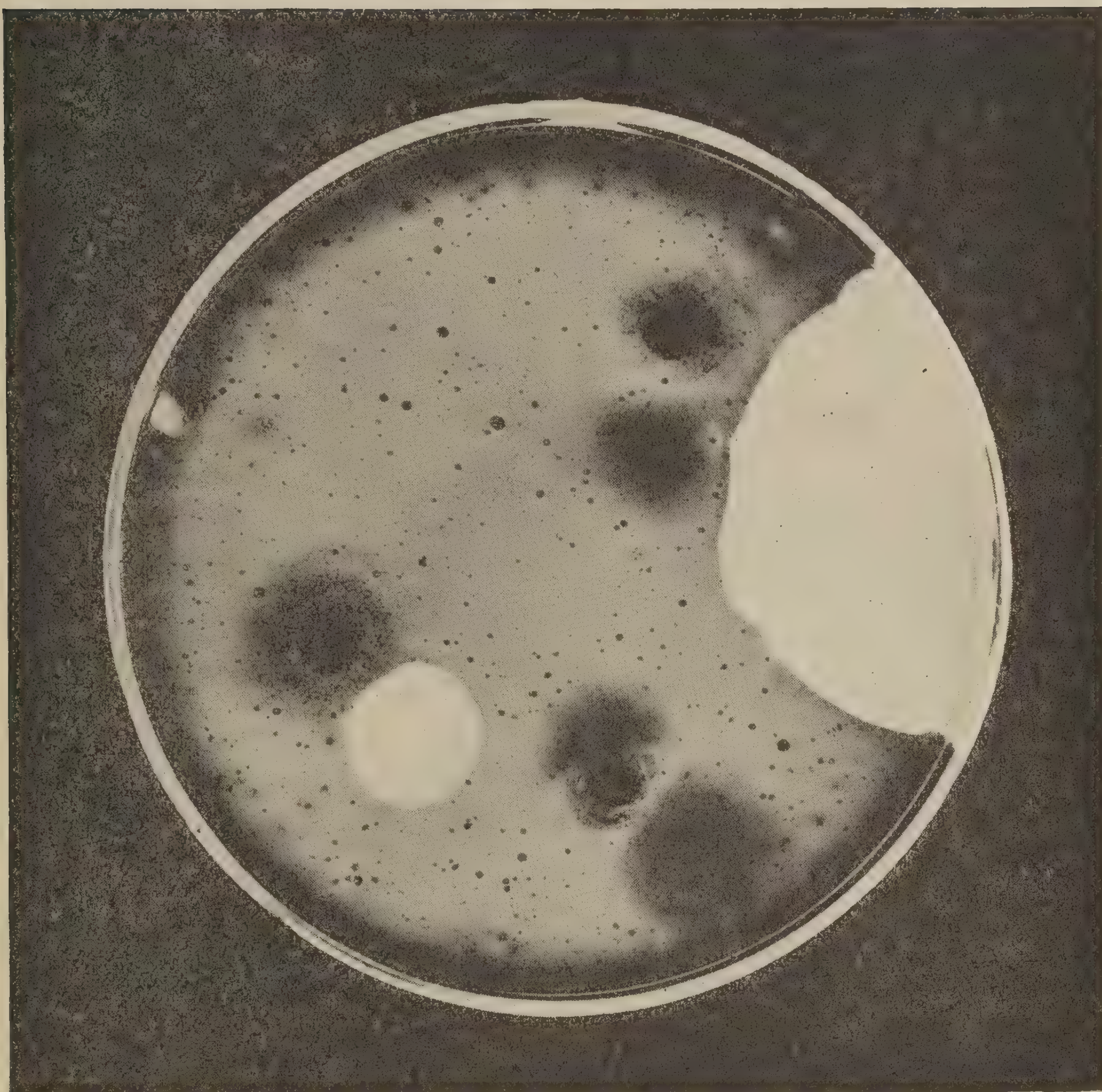

FIG. 42b.

By rinsing the tubes with 50 cubic centimeters of sterile water it was found that this rinse water commonly contained several thousand bacteria per cubic centimeter. Photographs of two of the plates made from this rinse water may be seen in Fig. 42. It was found that the brine itself increased in germ content very rapidly from day to day. At three days old, it contained from one to two thousand bacteria per cubic centimeter (see Fig. 43) and at ten days, it contained very high numbers, including many liquifying organisms. It was evident from the results of these experiments that the brine treatment is not satisfactory for keeping the tubes sterile.

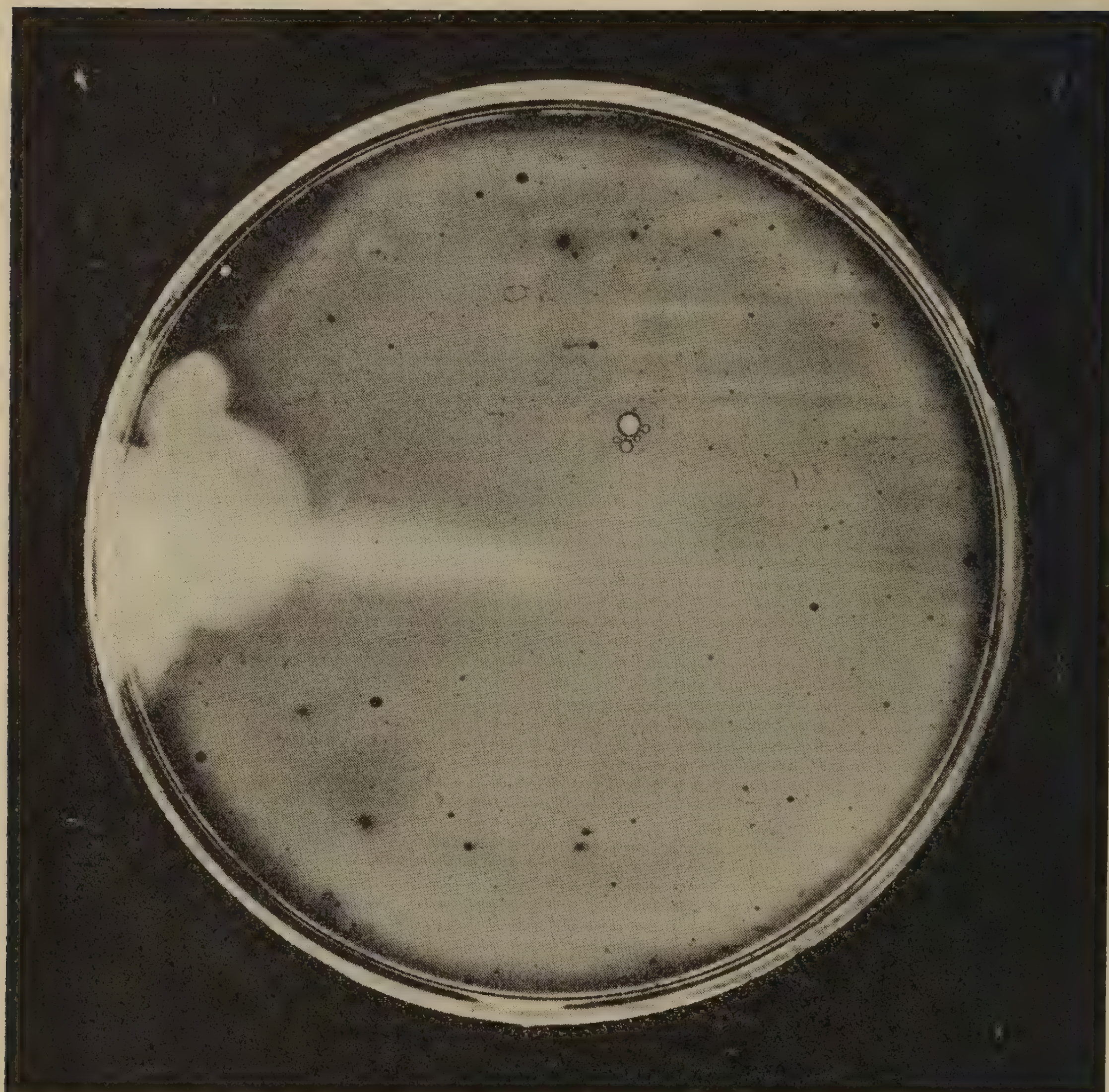

FIG. 43—Plate showing numbers of bacteria in .2 cc. of brine which had been used three days for soaking the rubber parts of the milking machines

SIXTH TREATMENT OF THE MACHINES.

The next change in the treatment of the machines was to immerse the tubes and teat cups in a borax solution made by dissolving one pound of powdered borax in fifteen quarts of water after the machines were washed as before. The tubes were placed in this solution and allowed to remain until needed for the next milking.

Tests made by rinsing the tubes with sterile water showed a germ content varying from a few hundred up to several thousand bacteria per cubic centimeter of this rinsing water, showing that this borax solution did not thoroughly sterilize the tubes. Photographs of two of the plate cultures made from the water with which the inside of the tubes were rinsed are shown in Fig. 44.

FIG. 44a—Plates showing numbers of bacteria in water used for rinsing inside of rubber tubes which were treated with borax solution, .1cc. and .5 cc. of rinse water used for plates.

A few of the experiments in Table 31 show a smaller germ content for the machine drawn milk than for the hand drawn milk, but in most of the tests the germ content of the machine milk is considerably higher than for that drawn by hand. In some cases the difference is very striking. Evidently this treatment did not keep the machines sterile.

SEVENTH TREATMENT OF THE MACHINES.

Thus far the sterilizing in steam and the treatment of the tubes in the formalin bath are the only methods which kept the tubes in a satisfactorily sterile condition. In the other

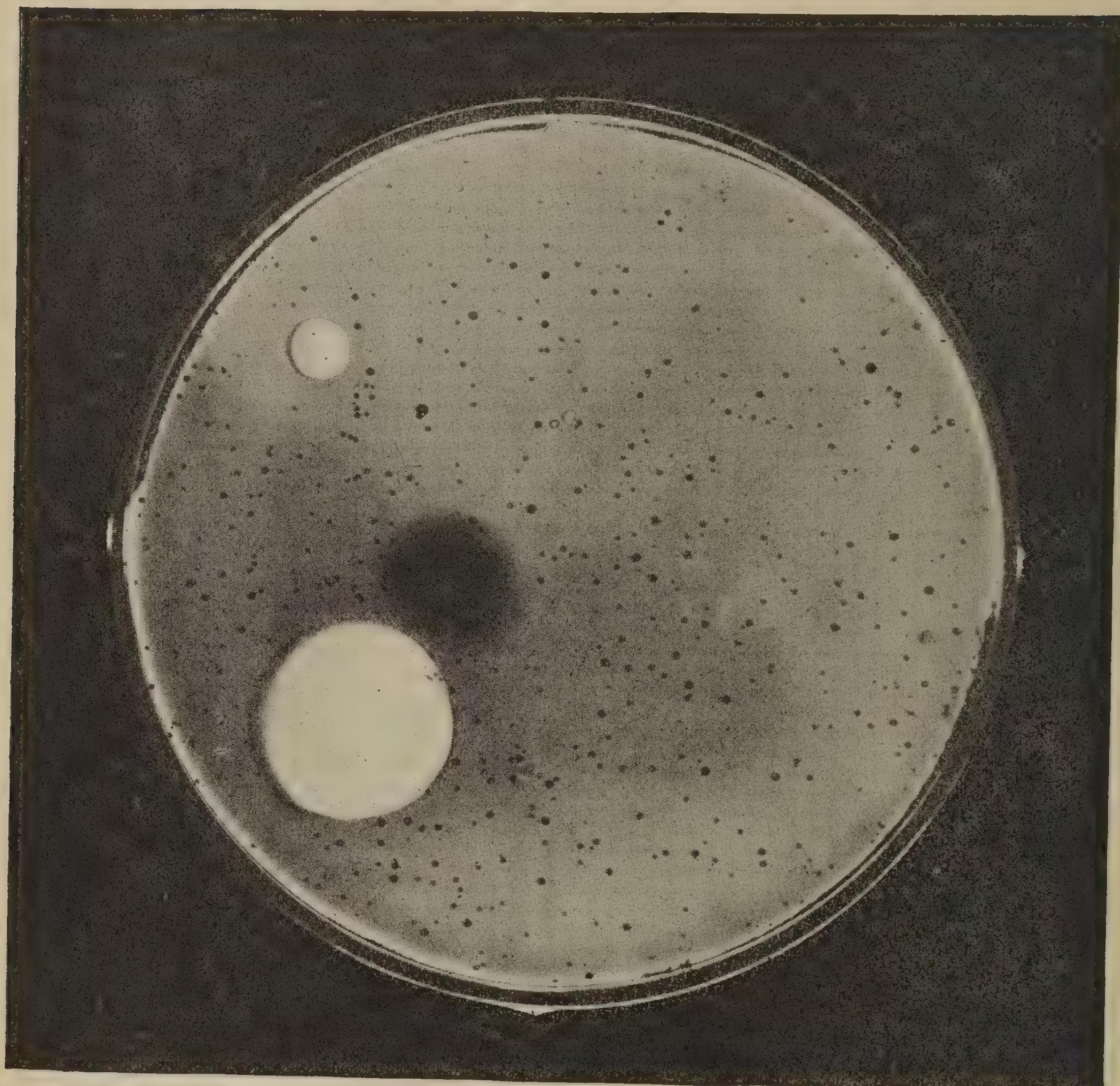

FIG. 44b.

methods used, the bacteria accumulating in the tubes became more and more abundant as time went on. Of the methods which were efficient in sterilizing the tubes the formalin treatment was the most promising since it served to preserve the rubber as well as to sterilize the tubes. As previously stated, the steam sterilizing was not feasible because of its injurious effect on the rubber. At this point it was decided to return to the formalin treatment.

For the experiments given in Table 31, the tubes were treated in a formalin solution as already described in connection with Table 28, but in this case a somewhat stronger solution was used; 3½ per cent of formalin being used instead of 2½ in order to make sure that the tubes should be thoroughly sterilized between milkings. This treatment proved to be very

efficient in destroying the bacteria in the tubes. Frequently they were found to be absolutely sterile, while in other cases an occasional organism was found, but in no case were there enough bacteria found in the tubes to have any effect on the germ content of the milk passing through the machine.

TABLE 31.

Comparison of hand and machine drawn milk. After washing all tubes and teat cups placed in a borax solution (1 pound borax in 15 quarts of water) till needed for use.

Date	Number of Experiment	Method of Milking	Time of Milking	Total Bacteria	Acid Bacteria	Rapid Liquefying Bacteria	Slow Liquefying Bacteria
Jan. 14	458	Machine	P. M.	31,580	760	5,100	40
		Hand	P. M.	11,000	4,450	40	1,325
Jan. 15	460	Machine	P. M.	10,200	1,040	2,960	60
		Hand	P. M.	6,660	2,435	60	1,050
Jan. 16	462	Machine	A. M.	17,715	2,100	1,550	835
		Hand	A. M.	6,075	1,600	0	440
Jan. 16	465	Machine	P. M.	8,035	1,600	215	900
		Hand	P. M.	12,715	1,515	35	875
Jan. 17	467	Machine	A. M.	20,085	3,215	1,865	265
		Hand	A. M.	9,375	1,785	35	500
Jan. 17	474	Machine	P. M.	9,600	1,000	1,460	380
		Hand	P. M.	6,640	610	90	200
Jan. 18	476	Machine	A. M.	12,500	2,420	780	620
		Hand	A. M.	3,010	460	0	335
Jan. 18	481	Machine	P. M.	4,215	850	1,065	65
		Hand	P. M.	23,565	1,735	60	3,290
Jan. 19	483	Machine	A. M.	21,265	4,115	1,735	700
		Hand	A. M.	5,035	1,140	75	690
Jan. 20	487	Machine	A. M.	18,900	2,435	2,015	265
		Hand	A. M.	8,675	5,335	0	2,960
Jan. 21	489	Machine	P. M.	46,300	650	13,250	0
		Hand	P. M.	9,040	2,920	290	400
Jan. 21	493	Machine	P. M.	15,415	2,485	1,315	165
		Hand	P. M.	3,415	1,500	0	725
Averages		Machine		17,817	1,889	2,725	362
		Hand		8 767	2,123	56	1,065

It seemed to the writer that the milk drawn through the machines when they were thoroughly sterilized should contain a very much smaller number of bacteria than milk drawn into the covered pail which was used in these experiments, since in the former case the milk passed directly from the udder into the closed pail through closed tubes and was entirely excluded

from contact with the stable air, while in the latter case a certain amount of dust and bacteria could drop into the four inch opening in the covered pail. Contrary to expectation, the germ content of the machine drawn milk continued to be

TABLE 32.

Comparison of hand and machine drawn milk. After washing all rubber tubes and teat cups placed in a 3.5 per cent. solution of formalin.

Date	Number of Experiment	Method of Milking	Time of Milking	Total Bacteria	Acid Bacteria	Rapid Liquefying Bacteria	Slow Liquefying Bacteria	Hours to Curdling
1906		Machine	P. M.	570	220	0	0	64*
Jan. 23	497	Hand	P. M.	2,250	960	16	375	53
Jan. 24	499	Machine	A. M.	24,330	6,830	120	1,830	64*
		Hand	A. M.	18,950	2,730	225	1,500	57
Jan. 24	560	Machine	P. M.	5,710	960	360	120	64*
		Hand	P. M.	875	375	8	100	64*
Jan. 25	512	Machine	A. M.	7,275	1,260	110	350	64*
		Hand	A. M.	5,025	1,100	60	680	50
Jan. 25	519	Machine	P. M.	3,650	750	20	160	77
		Hand	P. M.	3,850	520	20	50	82
Jan. 26	521	Machine	A. M.	5,520	1,275	90	200	64*
		Hand	A. M.	6,225	970	20	60	64*
Jan. 26	526	Machine	P. M.	2,525	480	125	170	64*
		Hand	P. M.	2,225	910	0	375	100
Jan. 27	528	Machine	A. M.	12,400	2,560	160	250	64*
		Hand	A. M.	11,440	2,340	40	525	41*
Averages		Machine		7,857	1,791	123	385	65
		Hand		6,355	1,238	48	458	63

higher than that of the hand drawn milk in the majority of cases, as may be seen in Table 32.

By the use of the connectors with the direct air intakes, the surging of the milk in the tubes was practically stopped, and it was believed that there must be some other explanation for the higher germ content of the machine drawn milk.

EIGHTH TREATMENT OF THE MACHINES.

At each pulsation of the machine, the air rushes in and relieves the vacuum in the teat cup. It was thought that possibly some bacteria might be drawn into the milk with the air taken in from the stable atmosphere. In order to determine this, a thin layer of absorbent cotton was placed in the air

relief in the teat cup connector shown in Fig. 41. A cotton filter was also placed in the air relief on the head of the machine where a portion of the air is taken in at each

TABLE 33.

Comparison of hand and machine drawn milk. Previous formalin treatment continued. Cotton filters used on machines.

Date	Number of Experiment	Method of Milking	Time of Milking	Total Bacteria	Acid Bacteria	Rapid Liquefying Bacteria	Slow Liquefying Bacteria	Keeping 70° F.
1906		Machine	A. M.	2,120	50	16	67	132
Jan. 29	530	Hand	A. M.	8,700	1,000	0	900	40*
Jan. 29.	533	Machine	P. M.	380	80	16	75	47
		Hand	P. M.	2,150	1,090	0	125	39
Jan. 30	535	Machine	A. M.	2,580	1,120	33	150	57
		Hand	A. M.	10,830	2,500	33	330	40*
Jan. 30	540	Machine	P. M.	760	550	16	165	48
		Hand	P. M.	3,875	600	16	185	39
Jan. 31	542	Machine	A. M.	2,425	890	42	260	56
		Hand	A. M.	7,750	2,650	0	100	40*
Feb. 1	548	Machine	A. M.	870	450	0	42	88*
		Hand	A. M.	7,700	1,700	33	500	—
Feb. 1	553	Machine	P. M.	1,070	280	42	25	79*
		Hand	P. M.	7,760	1,280	25	575	96
Feb. 1	558	Machine	P. M.	1,040	350	0	30	120
		Hand	P. M.	2,510	475	0	160	127*
Feb. 3	560	Machine	A. M.	800	110	50	90	181
		Hand	A. M.	3,050	840	0	125	51
Feb. 5	562	Machine	A. M.	1,900	525	0	50	86
		Hand	A. M.	1,990	560	50	260	64*
Feb. 5	564	Machine	P. M.	710	300	8	25	99
		Hand	P. M.	2,025	810	66	310	101
Feb. 6	566	Machine	A. M.	4,650	2,525	0	115	88*
		Hand	A. M.	3,620	1,575	0	135	85
Feb. 6	584	Machine	P. M.	160	135	0	8	
		Hand	P. M.	1,325	535	8	85	
Feb. 9	586	Machine	A. M.	120	17	0	0	
		Hand	A. M.	3,775	1,015	0	190	
Feb. 9	594	Machine	P. M.	4,085	1,515	0	100	
		Hand	P. M.	1,350	500	50	300	
Averages		Machine		1,578	622	14	80	72
		Hand		4,560	1,142	18	280	38

pulsation. By using the cotton filters in this way, all of the air which gained access to the milk had to pass through the cotton, which would prevent the bacteria from passing through.

A series of experiments conducted when these filters were used, is given in Table 33. It will be noticed by a study of the column marked "Total Bacteria," that the relation existing between the hand and the machine drawn milk is entirely different from that shown in the previous tables. In nearly every case the germ content was decidedly smaller in the milk drawn through the machines. In some cases the numbers are

TABLE 34.

Comparison of hand and machine drawn milk. Previous formalin treatment continued, changed to teat cup connectors without air relief.

Date	Number of Experiment	Method of Milking	Time of Milking	Total Bacteria	Acid Bacteria	Rapid Liquefying Bacteria	Slow Liquefying Bacteria	Keeping 70° F.
Feb. 14	612	Machine	P. M.	7,100	2,600	58	192	55*
		Hand	P. M.	1,330	425	8	133	39
Feb. 15	622	Machine	P. M.	1,260	375	33	117	72
		Hand	P. M.	590	250	0	0	92
Feb. 16	624	Machine	A. M.	3,620	1,000	17	125	58
		Hand	A. M.	10,460	3,520	33	858	58
Feb. 16	630	Machine	P. M.	5,860	1,700	0	342	68
		Hand	P. M.	4,400	675	8	150	94
Feb. 19	636	Machine	P. M.	3,425	2,230	17	25	68
		Hand	P. M.	880	470	0	40	70
Feb. 21	644	Machine	P. M.	5,100	2,120	17	133	70
		Hand	P. M.	370	130	0	50	48
Feb. 22	646	Machine	A. M.	3,525	1,580	0	233	76
		Hand	A. M.	15,930	3,080	67	350	48
Feb. 23	654	Machine	A. M.	6,335	3,880	0	66	53
		Hand	A. M.	7,240	700	67	67	52
Feb. 26	662	Machine	A. M.	10,570	3,380	0	150	87
		Hand	A. M.	3,725	680	0	142	80
Feb. 26	664	Machine	P. M.	4,735	2,660	8	67	119
		Hand	P. M.	1,090	350	0	17	94
Feb. 27	666	Machine	A. M.	12,020	4,950	25	250	88
		Hand	A. M.	45,720	32,150	317	92	59
Feb. 27	668	Machine	P. M.	27,235	14,060	125	33	63
		Hand	P. M.	1,785	700	0	100	63
Feb. 28	670	Machine	A. M.	28,850	11,740	16	233	95
		Hand	A. M.	11,835	3,140	0	325	62
Mar. 1	676	Machine	A. M.	25,635	13,020	17	625	68
		Hand	A. M.	2,325	1,275	8	117	80
Mar. 2	684	Machine	P. M.	27,550	12,840	8	992	90
		Hand	P. M.	4,330	850	100	275	103
Averages		Machine		11,521	5,209	22	238	75
		Hand		7,467	3,226	40	181	69

very small, as in experiments Nos. 533, 540, and 586. In many of the tests the difference in germ content of the hand and machine drawn milks is very marked. The average for the whole series shows that the machine samples contained about one-third the number of bacteria that was found in the hand drawn milk. It is quite evident from these experiments that the air drawn into the machines carried in a great many bacteria and was doubtless the cause of the high numbers in the previous experiments where the machines were sterile.

In order to be sure that the cotton filters were the cause of the greatly decreased germ content, another series of tests was made where the conditions were the same, except that the cotton filters were omitted. The results are given in Table 34. It was found that in most cases when the filters were not used, the germ content of the machine milk was decidedly higher than that of the hand drawn milk in the majority of previous experiments which have been given. In these experiments, the machines were found to be completely sterilized by the formalin treatment, so that the larger germ content was not due to the condition of the machines. It seems evident from these results that the large germ content was due to the bacteria drawn into the milk from the stable atmosphere.

THE LAST TREATMENT OF THE MACHINES.

Lime water is supposed to be a good antiseptic and in some degree at least a germicide. One series of experiments was made where the rubber tubes and teat cups were treated with a lime water solution, the other part of the treatment of the machines being the same as in the other tests.

The experiments given in Table 35 will indicate the results obtained by this treatment. It was found by testing the tubes that considerable numbers of bacteria remained in them from one milking to the next in spite of the careful washing. Sometimes several thousand bacteria were found per cubic centimeter in the water with which the tubes were rinsed.

It will be seen that the machine drawn milk normally contained many more bacteria than the milk drawn by hand, the difference being much greater in the experiments in this table than in those where the tubes were treated with formalin, all other conditions being similiar. While the lime solution would not be objectionable so far as its effect upon the wholesomeness of the milk is concerned, it is evident that it is not at all satisfactory as a means of sterilizing the tubes. So far

as these experiments go, the formalin treatment is the only one which seems to be efficient in sterilizing the tubes and which does not at the same time injure the rubber. By thoroughly rinsing the tubes just before use the formalin is so

TABLE 35.

Comparison of hand and machine drawn milk. After washing all tubes and teat cups were placed in a solution made of 1 pound lime in 2 pails of water. Connectors with air-relief used but no cotton filters.

Date	Number of Experiment	Method of Milking	Time of Milking	Total Bacteria	Acid Bacteria	Rapid Liquefying Bacteria	Slow Liquefying Bacteria	Keeping 70° F.
1906		Machine	A. M.	51,140	150	317	158	—
Sept. 20	921	Hand	A. M.	4,750	510	100	367	—
Sept. 20	926	Machine	P. M.	14,130	4,650	275	583	—
		Hand	P. M.	980	600	33	442	—
Sept. 21	928	Machine	A. M.	15,900	3,460	2,667	942	—
		Hand	A. M.	2,775	1,740	0	550	—
Sept. 24	935	Machine	P. M.	39,430	3,350	550	5,150	63
		Hand	P. M.	4,010	1,700	0	100	68
Sept. 25	937	Machine	A. M.	5,230	1,100	500	1,300	65*
		Hand	A. M.	9,270	2,000	84	800	41*
Sept. 25	941	Machine	P. M.	5,600	1,000	300	300	55*
		Hand	P. M.	5,400	3,500	50	400	50
Sept. 26	943	Machine	A. M.	327,600	293,200	400	880	65*
		Hand	A. M.	4,200	300	17	400	41*
Sept. 26	945	Machine	P. M.	16,130	10,020	0	466	65
		Hand	P. M.	320	130	0	100	49
Sept. 27	947	Machine	A. M.	94,700	1,725	575	575	41*
		Hand	A. M.	24,030	22,430	133	300	41*
Sept. 28	953	Machine	A. M.	49,230	4,430	1,233	3,633	—
		Hand	A. M.	6,320	1,320	83	330	—
Sept. 28	962	Machine	P. M.	6,080	3,960	120	540	—
		Hand	P. M.	2,940	2,400	0	17	—
Averages		Machine		55,367	29,731	630	1,320	59
		Hand		5,908	3,296	45	164	48

completely removed that no trace of it could be found in the milk, even by the most sensitive chemical test.

KEEPING QUALITY OF THE MILK.

In many of the experiments, the keeping quality of the milk was determined by the number of hours which it would keep before curdling, when kept at a constant temperature of 70° F. It may be seen by studying the tables that in the ma-

jority of cases the machine drawn milk kept longer than the milk which was drawn by hand. While this was not always true, it was so in most cases, even when the germ content of the milk was as high or higher than that of the hand drawn milk. This is illustrated in Table 35 where the average germ content of the machine drawn milk was 55,000 and the hand drawn milk 5,900 bacteria per cubic centimeter. In spite of this, the machine drawn samples kept on an average of 59 hours before they curdled, while the hand drawn milk averaged but 48 hours. A similar relation is shown in Tables 32 and 34.

The greatest difference in the keeping quality is shown in Table 33 where the cotton filters were used and the germ content of the machine milk averaged much lower than that of the hand milk. In this series of experiments, while the milk drawn by hand curdled on an average of 36 hours, that drawn by machine kept 72 hours before curdling.

MILKING MACHINES.

PART II.—EFFECT UPON MILK YIELD.

BY C. L. BEACH.

TABLE 36.

HAND AND MACHINE MILKING.

No. of Cows	Yield of Milk in Successive Periods of 7 Days.		
	Period I Hand Milking	Period II Machine Milking	Period III Hand Milking
10	902.1*	803.9	911.3
10	871.1	834.1	836.6
9	788.3	704.0	707.9
4	488.6	472.7	481.2
33	3050.1	2814.7	2937.0
Milk yield .77 pound per cow per day less in Period II.			

TABLE 36.—When milked by hand, thirty-three cows gave 2993.5 pounds of milk in seven days. The yield of the same cows when milked with the machine was 2814.7 pounds in seven days. The yield from machine milking was 178.8 pounds less in the seven days than from hand milking, or about (.77 pound) three-fourths pound less per cow per day.

* All the cows in the herd, even those not milked with machines made a considerable shrinkage in milk yield.

TABLE 37.

WEEKLY MILK YIELD OF SIX COWS MILKED WITH MACHINE, JANUARY 3–MARCH 6.

No. of Cow	Month of Lactation	1st Week Pounds	2d Week Pounds	3d Week Pounds	4th Week Pounds	5th Week Pounds	6th Week Pounds	7th Week Pounds	8th Week Pounds	9th Week Pounds
1	5	189.4	185.0	198.6	200.0	196.8	188.6	197.1	187.5	185.0
2	8	87.7	87.1	88.3	90.8	96.6	87.9	91.4	87.0	83.9
3	3	144.9	143.7	159.0	153.6	133.6	138.5	131.7	113.6	98.8
4	12	73.8	74.9	74.5	75.0	80.4	78.2	80.9	80.4	79.0
5	10	55.4	56.4	61.8	57.2	58.5	56.6	67.9	50.2	53.6
6	10	67.5	59.0	58.2	58.6	52.4	48.5	47.5	43.3	32.8
	8	618.7	606.1	640.4	635.2	618.3	598.3	616.6	562.0	535.1

Calculated shrinkage 6.8 per cent. per month.

TABLE 37.—The yield of six cows milked continuously with the milking machine for nine weeks was 2809.5 pounds in the first half of the trial and 2621.1 in the second half. The difference in yield is equivalent to a shrinkage of 6.8 per cent. per month.* The average period of lactation was the eighth month.

* Bulletin 26, Storrs Experiment Station, p. 25.
Henry's Feeds and Feeding, p. 408.
Bulletin 210, Geneva Experiment Station, p. 384.

TABLE 38.

YIELD OF SIX COWS MILKED WITH MACHINE, MARCH 7–MAY 8.

Number of Cow	Month of Lactation	1st Week Pounds	2d Week Pounds	3d Week Pounds	4th Week Pounds	5th Week Pounds	6th Week Pounds	7th Week Pounds	8th Week Pounds	9th Week Pounds
1	7	169.2	167.5	169.1	180.3	175.3	179.7	177.6	176.2	185.8
7	2	209.0	195.9	195.0	200.7	199.1	190.5	185.9	186.9	188.7
8	3	131.0	135.2	131.6	136.7	130.6	125.9	129.8	131.5	126.9
9	2	232.0	216.8	215.4	214.3	195.8	189.5	175.1	181.5	187.7
10	2	105.8	105.0	104.7	107.8	104.9	99.6	98.1	98.6	102.0
11	2	91.6	87.9	83.9	83.9	86.0	77.8	78.7	81.7	87.5
	3	958.6	908.3	899.7	922.7	891.7	863.0	845.2	856.4	878.6

Calculated shrinkage 5.9 per cent. per month.

TABLE 38.—The yield of six cows milked continuously with the milking machine for nine weeks was 4135.1 pounds in the first half of the trial and 3889.0 pounds in the second. The average period of lactation was the fifth month. The difference in yield is equivalent to a shrinkage of 5.9 per cent. per month.

Table 39.

Yield of Eight Cows Milked With Machine, May 2–29.

No. of Cow	Month of Lactation	1st Week Pounds	2d Week Pounds	3d. Week Pounds	4th Week Pounds
1	8	185.8	179.4	174.0	171.7
7	4	188.7	185.3	176.0	194.2
9	4	187.7	171.7	161.5	173.0
12	1	230.1	228.4	228.2	227.0
13	1	198.6	204.2	196.6	190.7
14	2	225.4	222.1	223.4	226.3
15	1	240.7	232.3	217.6	218.8
16	3	129.0	132.2	130.8	130.8
	3	1586.0	1555.6	1508.1	1532.5
Calculated shrinkage 3.2 per cent. in two weeks					

Table 39.—Eight cows were milked continuously for four weeks with the milking machine. The yield of milk during the first two weeks was 3141.6 pounds and 3040.6 pounds in the second two weeks. The difference in yield is equivalent to a shrinkage of 3.2 per cent. in the two weeks. The average period of lactation was the third month.

TABLE 40.
SUMMER SHRINKAGE IN MILK FLOW—COWS MILKED WITH MACHINE.

Number of Cow	Month of Lactation	Milk Yield in Pounds: Period 1 6/6–7/3	Period 2 7/4–7/31	Period 3 8/1–8/28	Period 4 8/29–9/25	Period 5 9/4–10/24
7	5	677	618	538	561	493
12	2	769	574	458	562	433
17	1	446	423	390	326	275
16	4	429	350	289	254	209
11	3	338	308	268	208	194
15	2	719	563	369	338	352
9	5	583	422	396	283	251
18	2	622	389	316	243	218
13	2	579	444	281	199	170
14	3	766	622	579	529	468
19	3	481	429	415	431	394
20	2	786	592	491	591	618
21	1	616	512	408	386	241
6	1	720	639	571	532	461
8	6	529	340	327	256	174
3	8	412	290	266	270	281
10	5	396	307	262	206*e*	
1	9	575	436	340*c*		
5	15	287	188	189*c*		
22	1		720*a*	665	477	468
24	1			560*b*	522	458
23	1			447*b*	417	316
25	1				723*d*	663
	3.6	10,730	9,366	8,825	8,314	7,137
Shrinkage from preceding period			19.4%	16.5%	8.5%	12.0%

Average shrinkage for four Periods, 14.1 per cent.
(*a*) Excluded in calculating shrinkage for Period II.
(*b*) Excluded in calculating shrinkage for Period III.
(*c*) (*d*) Excluded in calculating shrinkage for Period IV.
(*e*) Excluded in calculating shrinkage for Period V.

Table 40. About twenty cows were milked with the machine from June 6 to October 24. The table gives the yield of milk of each cow for each period of four weeks; also the average per cent of shrinkage for each period. The reader should bear in mind that the change from June days and fresh feed to "dog days," "fly time" and sparse pastures is a trying

one for dairy animals. The shrinkage in the milk flow at this time is much greater than at any other season of the year. It is not uncommon for herds to decrease from 25 to 40 per cent. or more in yield in the four months from June to September. Cows 17 to 25 inclusive had not previously been milked with the machine. If the animals had been stripped by hand after each milking the shrinkage would not have been as great as is here reported.

Table 41.

Summer Shrinkage in Milk Flow—Cows Milked by Hand.

	Number of Cows	Month of Lactation at Beginning	Yield of Milk Per Cow Per Day.				
			Period 1.	Period 2.	Period 3.	Period 4.	Period 5.
Vt. Exp. Station Herd, 1906, Shrinkage from preceding period,	26	5.2	6/3–6/16 22.5lbs.	7/1–7/14 18.7lbs. – 16.8%	7/29–8/11 15.2lbs. – 18.8%	8/26–9/9 12.0lbs. – 21.0%	9/23–10/6 12.3lbs. – +2.5%
N. J. Exp. Station, Herd, Bulletin 77, Shrinkage from preceding period,	5	2.4	6/1–6/30 33.1lbs.	7/1–7/31 30.1lbs. 9.0%	8/1–8/31 25.1lbs. – 16.6%	9/1–9/30 21.1lbs. – 15.9%	10/1– /31 17.1lbs. – 19.0%
Storrs Exp. Station Herd, 1900 Shrinkage from preceding period,	19	3.2	6/3–6/30 24.6lbs.	7/1–7/28 21 7lbs. 11.4%	7/29–8/25 17.7lbs. 18.4%	8/26–9/23 14.0lbs. 20.9%	9/24– /21 12.4lbs. 11.4%
Storrs Exp. Station Herd, 1902, Shrinkage from preceding period,	16	6.5		7/16–7/22 16.8lbs.	8/13–8/19 15.5lbs. 7.7%		
Storrs Exp. Station Herd, 1903, Shrinkage from preceding period,	18	6.6		7/21–7/27 16.2lbs.	8/18–8/24 14.9lbs. 8.0%		
Storrs Exp. Station Herd, 1905, Shrinkage from preceding period,	24	4.5	6/5–7/2 24.1lbs.	7/3–7/30 22.0lbs. – 8.7%	7/31–8/27 20.1lbs. – 8.6%	8/28–9/24 17.7lbs. – 11.9%	9/25– /22 16.3lbs. – 8.0%
Storrs Exp. Station Herd, 1906, Shrinkage from preceding period,	3	3	6/6–7/3 30.7%	7/4–7/31 26.7% 13.0%	8/1–8/28 23.1% 12.7%	8/29–9/25 21.4% 7.4%	9/26– /23 20.5% 4.2%
Average shrinkage from preceding period,				11.8%	12.9%	15.4%	2 8.0%

Average shrinkage for 4 periods. 12.0%.

The nineteen cows milked in Period 1, yielded 10,730 pounds of milk. In the next period, the same animals yielded (9366-720 a) 8,646 pounds of milk or 80.6 per cent. of the amount secured in the first period.

In the second period, twenty cows yielded 9,366 pounds of milk and in the third period (8825-100 b) 7,818 pounds or 83.5 per cent.

In the third period twenty cows yielded (8825-529 c) 8,296 pounds and in the fourth period (8314-723 d) 7,591 pounds or 91.5 per cent.

In the fourth period, twenty cows yielded (8314-206 d) 8,108 pounds of milk and in the fifth period 7,591 pounds or 91.5 per cent.

The shrinkage in milk yield for each period was 19.5%, 16.5%, 8.5%, and 12% or an average for the four periods of 14.1 per cent. These shrinkage factors should be compared with those given in Tables 40 and 41.

TABLE 42.

THE GOSHEN CREAMERY COMPANY.*

Year	Pounds of butter made in					Average decrease for 4 months.
	June	July	Aug.	Sept.	Oct.	
1893	10,595	10,097	7,884	6,930	6,286	
1894	10,137	8,456	6,458	5,154	4,646	
1895	9,994	9,371	8,056	6,474	4,950	
1896	8,204	8,220	7,478	8,267	7,441	
1897	11,417	10,973	9,781	9,293	8,183	
Total for 5 years	50,347	47,117	39,657	36,118	31,506	
Decrease from month preceding,		6.4%	15.8%	8.9%	12.8%	11.0%
Calculated decrease in milk production,†		8.6%	17.7%	10.9%	14.7%	12.9%

TABLE 42.—The Goshen Creamery Company reports the amount of butter made for each month in the year for five years. The average decrease for the four months is 11.0 per cent. On the assumption that the fat content of milk increased .1 per cent each month as the milk flow decreased, the calculated average shrinkage in the milk yield for the four months is 12.9 per cent

* From the Eighth Annual Report of Connecticut State Dairy Commissioner.

† Calculated decrease in milk production based on assumption of an increase of .1 per cent. per month in fat content of milk

Table 41. The daily milk yield during the summer months of 111 cows milked by hand is given in Table 41. The data is arranged in such a manner that comparisons may be made with Tables 40 and 42. The shrinkage from the first period to the second is 11.8 per cent; 12.9 per cent. from the second to the third; 15.4 per cent. from the third to the fourth, and 8.0 per cent. from the fourth to the fifth, or an average of 12.0 per cent. for the four periods.

This report of the results with milking machines is submitted without discussion or comment. No conclusions should be drawn from so limited an experience. The resignation of the writer and his withdrawal from the Station Staff while the experiment was in progress makes it necessary to offer this rather premature report of the preliminary work.

The first experience in the use of these machines is as much a test of the *skill* of the *operator* as of the efficiency of the method. From the experience thus far gained better results are anticipated in the future. Particular attention must be given to the proper adjustment of the teat cups and mouthpieces to the size of the teats of each cow. Each cow should always be stripped out clean by hand immediately after removing the machine. The failure to do this systematically no doubt affected the yields reported in Table 40. The constant stream of visitors and sightseers no doubt had some effect upon results.

Abortion.

By C. L. Beach.

The expulsion of the foetus at any time before the completion of the full period of normal pregnancy is termed abortion. The disease is dreaded by the breeder and dairyman, resulting as it does in the loss of the offspring and usually a diminished milk production. Contagious abortion varies in virulence due to varying potency of the germ, or to the susceptibility of the animal to attack. Sometimes every female in the herd will slink her calf, and again only a portion of the herd will be effected. The disease is often introduced into a healthy herd by the purchase of an infected animal, or through the bull being allowed to serve an aborting cow. The treatment for this disease is an isolation of all aborting animals and a thorough and continuous disinfection.

ABORTION IN COLLEGE HERD.

1. The disease was purchased. In 1903, six pure bred pregnant animals were added to the herd, and shortly after two aborted.

2. During the next three years twenty-four of the seventy-nine calvings were premature births. These figures

	Normal Calvings,	Premature Births.	Total Calvings.
First Year	14	12	26
Second Year	20	7	27
Third Year	21	5	26
Total	55	24	79

indicate that the contagion was not extremely virulent in this case or the treatment delayed to some extent the progress of the disease.

3. The premature births occurred at from 145 days to 262 days from time of conception, and the average of the twenty-four cases was 211 days.

4. The bull was not the sole means of spreading the disease in this instance. The twenty-four conceptions that terminated in premature births were the result of the matings of 15 different sires, eight of which were owned by parties remote from the effected herd.

5. Treatment. Disinfectants were used in the barn and the stable was white washed. At irregular intervals from one to two ounces of crude carbolic acid was fed to cows five or more months in calf. The aborting animals were isolated when possible, the foetal membranes thoroughly removed by the hand, and antiseptic douches used until discharge from vulva ceased. At frequent intervals each animal in the herd was sprayed with a disinfecting fluid about the vulva, root of tail and hind parts generally. The bulls were disinfected by injecting an antiseptic solution into the sheath before service.

6. Milk and fat yield during aborting period. It is frequently stated that an aborting cow is usually of little use in the dairy, and therefore it is best to fatten her and apply treatment to those that remain. In the table below the milk and fat yields of ten cows following a normal calving are compared with the milk and fat yields during the period of abortion. These cows, following a normal calving, averaged 5,892 pounds of milk and 282.8 pounds of fat in one year. During the next 2.1 years, or from one normal calving to the next normal calving which included the aborting period, these cows averaged 5,196 pounds of milk and 268.4 pounds of fat per year. The milk was 696 pounds or 12% less per year during the aborting period. These ten cows aborted seven months (average 211 days) after conception. The satisfactory yields are attributed in part to the complete removal of the after birth and the thorough disinfection of the animals after abortion.

7. Failure to breed after aborting. Only one of the twenty-four animals that experienced a premature birth failed to breed after aborting. This animal was killed and the Post Mortem examination showed the presence of an ovarian tumor which may or may not have been caused by the treatment administered to induce conception. Twenty-three of these cows produced a normal calf 461 days subsequent to abortion. Conception took place, therefore, on the average 177 days (461—284=177) or practically six months after aborting. Experience indicates that it is useless to attempt to breed a cow for four or five months subsequent to aborting. Time must be given to recuperate. The success in getting these cows in calf after the premature delivery is attributed in part to the use of the yeast treatment. A yeast cake dissolved for twenty-four hours in a pint of warm water was injected into the vagina several days in succession previous to the time of mating.

Milk and Fat Yields of Ten Cows Following Normal Calving Compared with Abortion Period.

Normal Calving			Abortion Period				
			From Normal to Nor Calving			Ave. Yield per Year	
No. of Cow	Yield of Milk 1 Year	Yield of Fat 1 Year	No. of Years	Milk Yield Pounds	Fat Yield Pounds	Milk Pounds	Fat Pounds
1	6811	308	2.31	13496	533	5842	231
2	6134	247	1.47	8639	346	5877	236
3	5546	312	2.33	11045	685	4738	294
4	5264	221	2.27	14475	672	6381	297
5	6225	298	2.39	16789	853	7029	356
6	5197	308	2.08	12158	855	5845	411
7	4338	238	2.08	7803	493	3751	237
8	5845	304	1.77	6913	385	3906	229
9	6244	274	2.00	8032	362	4016	181
10	7302	318	2.30	10251	487	4574	212
Avg.	5892	282.8	2.1			5196	268.4

Milk and Butter Yields of Heifers Compared with Mature Cows.

BY C. L. BEACH.

In Table No. 1 may be found the results of 3098 official milk and butter-fat records of Holstein-Friesian cows and heifers, published in Vol. 4 of the Year Book, and classified and averaged according to age. Several points of interest to students of dairy animals are exhibited in this compilation.

1. The quality of milk is quite uniform for animals of different ages. The milk of two-year-old heifers contained .2% (2-10) less of butter-fat than that of cows in the mature five-year-old form.

2. The calculated butter-fat yield at even age of two years is 9.05 pounds of butter-fat, and 14.35 pounds of butter-fat in seven days at even age of five years. From this it would appear that a heifer at two years of age may be expected to

TABLE No. 1.

Milk and Butter Yields Holstein-Friesian Cows, Vol. 4, Year Book.

Average Age of Cows			No. of Records	Average Fat Yield pounds	Average Milk Yield, pounds	Per Cent. of Fat in Milk
Years	Months	Days				
10 to 11			35	15.40	445.2	3.46
9 to 10			71	14.97	433.2	3.45
8 to 9			112	15.17	441.6	3.44
7 to 8			187	14.71	438.2	3.36
6 to 7			207	15.05	441.9	3.405
5	5	25	281	14.72	432.7	3.406
4	5	15	452	13.96	416.5	3.352
3	5	15	665	12.39	368.6	3.362
2	4	19	823	9.96	300.9	3.31
1	10	15	265	8.76	267.3	3.27

Calculated Yield at Even Age.

Age Years	Fat Yield, Pounds	Daily Increase in Pounds of Fat	(Based on 7 Day Yield)
5	14.35	.0031	From four to five years.
4	13.22	.0052	From three to four years.
3	11.31	.0062	From two to three years.
2	9.05		

give (9.05÷14.35=.631) 63.1%; at three years of age (11.31÷14.35=.788) 78.8%; at four years of age (13.22÷14.35=.921) 92.1% of the calculated yield at even age of five years or when in mature form.

3. The calculated yield at even age of three years is 11.31 pounds of butter-fat, and at two years of age 9.05 pounds of butter-fat. The productive capacity at three years was (11.31—9.05=2.26) 2.26 pounds more than at two years of age, or at the rate of (2.26÷365=.0062) .0062 pound of fat more per day. In the same manner the records at four years of age are 1.91 pound on fat more than at three years of age, or at the rate of .0052 pound more of butter-fat per day. The records at five years of age show a production of 14.35 pounds of butter-fat, which is 1.13 pound more than at four years of age, or at the rate of .0031 pound of butter-fat more per day.

4. The present requirements for admission to the Holstein-Friesian Advanced Registry is 7.2 pounds of butter-fat in seven days when calving at two years old or under two years. Every day of age from two to three years, from three years to four, and from four years to five, increase this requirement .00439 pound of butter-fat per day. The required increase factor, therefore, is uniform for each day older than two years. It would appear, from the last column in Table No. 1, that the actual daily increase in productive capacity from two to three years of age is .0062 pound of fat; from three to four years of age .0052 pound of fat, and from four to five years of age .0031 pound of fat.

Yields of Guernsey Heifers Compared With Mature Cows.

By C. L. Beach.

In Table No. 2 are exhibited the official milk and fat yield of four hundred cows and heifers, classified according to age. The two-year-old class averaged 352.8 pounds of butter-fat; the three-year-old class 403.9 pounds; the four-year-old class 433.5 pounds; the mature form class (five years old and over) averaged 455.7 pounds of butter-fat in one year. The two-year-old class averaged (352.8÷448.4=.774) 77.4%; the three-year-old class 88.6%, and the four-year-old class 95.1% of the yield of those five years old and over.

The requirements for admission to the Guernsey Advanced Registry is 250.5 pounds of fat if the record is commenced the day the animal is two years old or previous to that age. For each day the animal is over two years old at the beginning of the year's record, the amount of butter-fat she will be required to produce in the year will be established by adding one-tenth of a pound for each such day to the 250.5 pounds required when two years old.

This ratio is applicable until the animal is five years old, when the required amount will have reached 360 pounds, which will be the amount of butter-fat required of all cows five years old or over.

TABLE NO. 2.

From Guernsey Advanced Registry—Yields of Cows and Heifers.

Age of Animals Years	Months	No. of Records	Average Fat Yield, pounds	Average Milk Yield, pounds	Per Cent. of Fat in Milk
11	2.4	16	428.2	8750	4.90
9	6.2	19	476.8	9331	5.11
8	4.4	20	441.9	8490	5.20
7	4.6	23	470.8	9116	5.16
6	4.9	38	457.6	9085	5.04
5	7.3	29	448.4	8952	5.05
4	4.6	49	433.5	8495	5.10
3	4.8	69	403.9	7821	5.16
2	4.6	137	352.8	6914	5.10

Age Years	Months	Daily Increase in Pounds of Fat	(Based on Yearly Yield)
5	7.3	.033	From four to five years.
4	4.6	.082	From three to four years.
3	4.6	.138	From two to three years.
2	4.6		

The daily increase factor is established at .1 pound per day for each day older than two years. The last column of Table No. 2 shows, however, that the actual increase in production from two to five years of age is *not* a uniform increase. The three-year-old class gave .138 pound more of fat per day for each day older than the two-year-old class; the four-year-old class yielded .082 pound more of fat per day for each day older than the three-year-old class, and the five-year-old class yielded only .033 pound more of fat per day for each day over the age of the four-year-old class.

Sex of Calves dropped in Storrs College herd, ten years. Number of calves dropped.

C. L. BEACH.

Year	Total	Females	Males
1897	14	8	6
1898	21	7	14
1899	19	6	13
1900	16	6	10
1901	25	10	15
1902	22	7	15
1903	22	12	10
1904	18	9	9
1905	21	10	11
1906	23	8	15
Total........	201	83	118
Per cent......	100	41.3	58.7

The College herd is kept for instructional purposes and is composed of only pure bred cattle. Four breeds are represented, and the respective sires are required to do but limited service. During the ten years from 1897 to 1906, 201 calves were dropped, of which 41.3% were female and 58.7% were male.

In a small flock of Dorset sheep, five ewes and male at the start, the number of ram lambs was largely in excess of ewe lambs. Mr. Garrigus, the farm superintendent, reports that the first year with one crop of lambs there were one ewe and four bucks. All ewe lambs were kept in the flock for breeders. Males used were changed from year to year, but in every case were strong and vigorous. The second year with two crops of lambs there were three ewe and four buck lambs; the third year two ewe and five buck lambs, and the fourth year two ewe and eight buck lambs, or a total for four years of eight ewes and twenty-eight buck lambs.

Birth Weight of Calves.

Breed	Age	No. of Animals	Ave. Live Wgt. of Cows, lbs.	Birth Wgt. of Calves, pounds	Relative Wgt. of Calf to Dam in Per Cent.	Foetal Growth, Ave. per day, Lbs.
Holstein.....	mature	4	1190	107	9.0	.38
Ayrshire....	mature	7	965	77	8.0	.27
Guernsey....	mature	8	1024	79	7.7	.28
Jersey......	mature	11	898	67	7.4	.24
Jersev......	2 years	7	625	63	10.1	.22

The weight of calves at birth is in proportion to weight of dams. In proportion to their weight, heifers produce larger calves than mature cows. The Holstein calf appears to be larger than the Jersey at the time of birth, both absolutely and relatively to size of dam.

The foetal growth, average per day, was from .038 pound with Holstein calves to .022 pound with calves from Jersey heifers.

Tests of Cows for Advanced Registry.

By C. L. Beach.

Fay De Kol Burke, A. R. O. No. 5504. Sire, De Kol Burke; dam, Fay M. Breed, Holstein-Friesian. Age at time of calving, two years and five months. Required production, 7.858 pounds fat in seven days. Production 273.2 pounds milk, 3.12% fat, 8.533 pounds of fat. Milked three times per day. Feed, 91 pounds grain, 210 pounds silage and pasture. Test made May 2d to 8th, 1906. Owned by the Connecticut Agricultural College.

Attested by

Roy Tucker.

Petertje De Kol Burke, A. R. O. No. 5505. Sire, De Kol Burke; dam, Altoona Petertje A. Breed, Holstein-Friesian. Age at time of calving, two years, two months and twenty-four days. Required production, 7.59 pounds fat in seven days. Production 244.2 pounds of milk, 3.66% fat, 8.596 pounds of fat. Milked three times per day. Feed, 105 pounds of grain, 210 pounds silage, pasture. Test made May 2d to 8th, 1906. Owned by the Connecticut Agricultural College.

Attested by

Roy Tucker.

Name of Animal	OFFICIAL RECORDS OF PEN BRED COWS					Production		REQUIREMENTS		
	Breed	Age of Cows Years	Age of Cows Days	Name of Owner	Length of Test Days	Milk Pounds	Butter Fat Pounds	Milk Pounds	Fat Pounds	Butter
Fay De Kol Burke.....	Holstein	2	150	Conn. Agr'l Coll.	7	273.2	8.553		7.858	
Petertje De Kol Burke..	Holstein	2	89	Conn. Agr'l Coll.	7	244.2	8.956		7.590	
Alceyone of the Plain...	Ayrshire	10		Conn. Agr'l Coll.	365	8646.2	322.9	8500		375
Euratus Second........	Guernsey	4	300	Conn. Agr'l Coll.	365	8640.0	392.7		3.54	
Lady Sam.............	Ayrshire	6	50	Henry Dorrance	365	9530.0	348.8	8500		375
Rotha of Ridgeside.....	Ayrshire	3	230	Henry Dorrance	365			7147		308

Alceyone of the Plain, A. B. A. No. 1. Sire, (Pekin 4955); dam, (Isabell O. 13316.) Breed, Ayrshire. Age at time of calving, ten years. Required production, 8500 pounds of milk and 375 pounds of butter. Production during the year 8646.2 pounds of milk and 376.7 pounds of butter. Feed, 2337 pounds of grain, 144 pounds corn stover, 1414 pounds soiling crops, 10145 pounds silage and 928 pounds of hay. Test made from April 5, 1904, to April 4, 1905. Owned by the Connecticut Agricultural College.

Attested by

STORRS EXPERIMENT STATION.

Eurotas 2d, 409 A. R. O. Sire, (Fill Pail Star 4295); dam, (Eurotas 2537.) Breed, Guernsey. Age at beginning of test, four years and ten months. Required production, 354 pounds of butter-fat in one year. Production, 8640 pounds milk and 392.74 pounds of fat in one year. Feed, 2355 pounds of grain, 275 corn stover, 1064 pounds soiling crops, 10425 pounds silage and 950 pounds hay. Test made from March 22, 1905, to March (21), 1906. Owned by the Connecticut Agricultural College.

Attested by

HATCH MASS. EXPERIMENT STATION.

Lady Sam, No. 16286, A. B. A. Age at time of calving, six years and fifty days. Requirements for advanced registry, 8500 pounds of milk and 375 pounds of butter. Actual production, 9530 pounds of milk and 407 pounds of butter. Owned by Henry Dorrance, Plainfield, Connecticut.

Attested by

STORRS EXPERIMENT STATION.

Rotha of Ridgeside, No. 17360, A. B. A. Age at time of beginning test, three years and two hundred and thirty days.

Requirements for admission to advanced registry, 7147 pounds of milk and 308 pounds of butter. Actual production, (7330) pounds of milk and (370) pounds of butter. Owned by Henry Dorrance, Plainfield, Connecticut.

Attested by

STORRS EXPERIMENT STATION.

Milk From Different Breeds.

The milk of twenty-three cows, representing four different breeds, was analyzed for the first ten months of lactation. The average composition of the milk by breeds is shown in Tables 1 to 5.

The milk of the Holstein cows contained on the average 11.44% of total solids; the Ayrshire contained 12.26%; the Guernsey contained 13.56%, and the Jersey 14.37% of total solids.

The milk of the Holstein cows contained on the average 3.43% of fat; the Ayrshire 4%; the Guernsey 4.72%, and the Jersey 5.45% of fat.

The milk of the Holstein cows contained on the average 2.91% of Casein and Albumin; the Ayrshire 3.97%; the Guernsey 3.34%, and the Jersey 3.61%.

Table No. 1.

Average composition of milk of three Holstein Cows, one lactation. (10 months.)

Month	Total Solids Per Cent.	Fat Per Cent.	Casein and Albumin Per Cent.	Milk Sugar Per Cent.	Ash Per Cent.
1	11.05	3.26	2.64	4.33	.82
2	11.61	3.56	3.02	4.28	.75
3	11.04	3.20	2.65	4.47	.72
4	10.91	3.26	2.72	4.21	.72
5	11.51	3.40	2.84	4.52	.75
6	11.10	3.26	2.68	4.42	.74
7	11.82	3.20	2.80	4.52	.71
8	11.39	3.37	2.95	4.29	.78
9	12.11	3.70	3.22	4.44	.75
10	12.85	4.10	3.47	4.55	.73
Avg.	11.49	3.43	2.91	4.40	.75

TABLE No. 2.

Average composition of milk of five Ayrshire cows, one lactation. (10 months.)

Month	Total Solids Per Cent.	Fat Per Cent.	Casein and Albumin Per Cent.	Milk Sugar Per Cent.	Ash Per Cent.
1	12.28	4.10	2.87	4.60	.71
2	12.18	4.36	2.72	4.38	.72
3	11.84	3.80	2.83	4.49	.72
4	11.81	3.60	2.77	4.74	.70
5	11.94	3.74	2.92	4.60	.67
6	12.10	3.92	2.94	4.52	.72
7	12.08	3.86	3.08	4.42	.72
8	12.43	4.02	3.29	4.41	.71
9	12.89	4.30	3.77	4.04	.78
10	13.05	4.30	3.52	4.45	.78
Avg.	12.26	4.00	3.07	4.41	.72

TABLE No. 3.

Average composition of milk of five Guernsey cows, one lactation. (10 months.)

Month	Total Solids Per Cent.	Fat Per Cent.	Casein and Albumin Per Cent.	Milk Sugar Per Cent.	Ash Per Cent.
1	13.41	4.80	3.03	4.81	.77
2	13.39	4.60	3.23	4.80	.76
3	13.66	4.74	3.16	5.04	.72
4	13.65	4.86	3.21	4.86	.72
5	13.21	4.60	3.23	4.67	.71
6	13.22	4.62	3.33	4.52	.75
7	13.39	4.40	3.46	4.79	.74
8	13,62	4.56	3.61	4.70	.75
9	13.99	4.94	3.54	4.73	.78
10	14.10	5.10	3.65	4.59	.76
Avg.	13.56	4.72	3.34	4.75	.75

TABLE No. 4.

Average composition of milk of ten Jersey cows, one lactation. (10 months.)

Month	Total Solids Per Cent.	Fat Per Cent.	Casein and Albumin Per Cent.	Milk Sugar Per Cent.	Ash Per Cent.
1	13.47	4.81	3.26	4.64	.76
2	13.44	5.06	3.25	4.44	.74
3	13.82	5.21	3.36	4.45	.80
4	13.92	4.95	3.44	4.77	.76
5	14.45	5.52	3.62	4.51	.80
6	14.74	5.75	3.78	4.41	.80
7	14.90	5.72	3.76	4.60	.82
8	14.88	5.65	3.93	4.49	.81
9	14.96	5.74	3.88	4.49	.85
10	15.06	6.10	3.82	4.31	.83
Avg.	14.37	5.45	3.61	4.51	.80

TABLE No. 5.

Average composition of milk of different breeds.

Breed	No. of Cows	Total Solids Per Cent.	Fat Per Cent.	Casein and Albumin Per Cent.	Milk Sugar Per Cent.	Ash Per Cent.
Holstein.....	3	11.49	3.43	2.91	4.40	.75
Ayrshire....	5	12.26	4.00	3.07	4.47	.72
Guernsey....	5	13.56	4.72	3.34	4.75	.75
Jersey......	10	14.37	5.45	3.61	4.51	.80

The milk of the Holstein cows contained on the average 4.40% of milk sugar; the Ayrshire 4.47%; the Guernsey 4.75%, and the Jersey 4.51%.

The milk of the Holstein cows contained on the average .75 per cent. of mineral matter; the Ayrshire .72 per cent.; the Guernsey .75 per cent., and the Jersey .80 per cent.

TABLE NO. 6.

Amount of ingredients for each pound of fat.

Breed	Solids not Fat, pounds.	Casein and Albumin, lbs.	Milk Sugar Pounds	Ash Pounds
Holstein........	2.35	.85	1.28	.22
Ayrshire........	2.07	.77	1.12	.18
Guernsey.......	1.88	.71	1.01	.16
Jersey..........	1.64	.66	.83	.15

As shown in Table No. 6, for each pound of fat in Holstein milk there is 2.35 pounds of solids not fat; 207 pounds in Ayrshire milk; 1.88 in Guernsey milk, and 1.64 pound in Jersey milk. For each pound of fat in Jersey milk there was (2.35—1.64=.71) .71 pound or 43% less of solids not fat. This characteristic of the milk of the Channel Island breeds explains in part their superior ability to produce butter, and butter fat economically.

TABLE NO. 7

Relation of milk constituents in total solids.

Amount in 100 pounds of total solids, per cent.

Breed	Fat	Casein and Albumin Lbs.	Milk Sugar	Mineral Matter
Holstein........	29.8	25.3	38.3	6.5
Ayrshire........	32.6	25.0	36.4	5.9
Guernsey.......	34.8	24.7	35.0	5.5
Jersey..........	37.9	25.1	31.4	5.5

The relation of the constituents in the total solids is shown in Table No. 7. In one hundred pounds of total solids, 29.8

parts consisted of fat in Holstein milk; 32.6 parts in Ayrshire milk; 34.8 in Guernsey milk and 37.0 parts in Jersey milk.

The milk sugar ranged from 38.3 parts in Holstein milk to 31.4 in Jersey milk. The ash ranged from 6.5% in Holstein milk to 5.5% of the total solids in Jersey milk.

The casein constituted about one-fourth of the total solids in the milk of each breed.

The total solids containing the largest amount of fat, contain proportionally less of milk sugar and ash.

Carbon Dioxide Under Sitting Hens.

By H. D. Edmond.

The following experiments were carried on to determine the carbon dioxide content of air in incubators and under sitting hens. Certain manufacturers of incubators have made extravagant claims for their machines because they contain a large amount of carbon dioxide during the incubation period and that they approximated the conditions in this respect as found under the hen. Whether carbon dioxide is essential to a perfect hatch and vitality in a chick is still an open question. This work is not complete enough to settle the question and there is very little data to be found on this subject. It is true, as shown by the following tables, that there is a much larger percentage of carbon dioxide under a sitting hen than in an incubator and it is also true that a hen hatches chickens with greater vitality than an incubator. Judging from the amount of carbon dioxide found under a hen it seems probable that it has no ill effect on the growth of the embryo chicken. It may have a retarding effect for it is known that eggs hatch about 24 hours sooner in an incubator than under a hen. This extra time may allow the yolks to become properly absorbed, thus producing a chicken of stronger vitality.

TABLE No. I.

Parts by weight of carbon dioxide in 10,000 parts of air found under sitting hens.

	Hens A	B	C	Barn
March 11	8.5	7.6	6.7	5.2*
March 12	4.9	4.9	6.9	4.4*
March 13	4.8	3.8	3.8	3.8†
March 14	5.9	5.8	6.3	5.9
March 15	5.7	6.6	5.0	3.8
March 16	——	——	——	——
March 17	——	5.2	3.4	——
March 18	3.5	5.2	5.2	3.9
March 19	5.1	6.9	6.9	4.8
March 20	4.4	4.4	4.4	3.0
March 21	5.7	5.5	5.5	4.3
March 22	——	——	——	——
March 23	4.5	6.8	6.8	3.6
March 24	——	——	——	——
March 25	6.8	11.3	9.2	3.9
March 26	6.6	11.0	13.2	3.9
March 27	4.5	15.5	15.7	3.8
March 28	6.7	22.5	15.7	3.9
March 29	4.5	20.1	22.1	3.9
March 30	——	——	——	——
March 31	3.4	21.1	16.4	2.8
April 1	3.4	22.0	17.6	3.8

*China Eggs. †Good Eggs under A and B.

In this paper are given tables showing the results of our work up to the present time. They are typical of the results found in all the work along this line at this station.

Pettenköfer's titration method, modified in some respects, was used to determine the amount of carbon dioxide. In Table I a flask of 500 c.c. capacity was used and air was aspirated through this flask. The air in the flask was displaced by that from under the hen. The aspiration method was used for simplicity after a test had been made to test the difference between this method and the one where the flask is filled with water and drawn off, the air from under the hen taking its place. No perceptible difference in results was found by the two methods. The flasks were filled by drawing 1000 c.c. of air through them in 1½ minutes. Duplicate samples drawn

at the same time agree very closely with results given here, showing that the figures for carbon dioxide are not much below the actual amount, which one might believe to be true if there was a large admixture of outside air with the small amount found under the hen.

This rapid method of drawing the air shows what a later method does not show so well, and that is, the uniform increase of carbon dioxide during the incubation period where a slower process was employed, as in Table II, where the hen would raise herself from the eggs or move about, thus seriously interfering with the taking of like samples because the conditions would be different each day. Samples of air were drawn from a hen setting on china eggs and from the air of the room.

Although there was a slightly higher amount under the hen than in the room no agreement could be found with the work of the Utah Station where as much CO_2 was found under the hen with china eggs as with good eggs.* In a large number of cases where china eggs were used or the chicks died in the shell as in another experiment carried on at this time, it was found that the air under the hen contained very little more carbon dioxide than the air of the room. No experiment was made to find the source of this increase. A little doubtless comes from the hen's body and some would come from respired air caught and held in the feathers of the hen as she pecked herself or adjusted the eggs.

Table I shows conclusively, as does Table II, that when a hen is setting on good eggs, the CO_2 can be accounted for by the CO_2 given off by the growing chick within the egg. Although variable, the amount of carbon dioxide in 10,000 pts. of air by weight does not exceed 6.7 pts. after the 13th under Hen A with china eggs, while under Hen B there is a gradual increase from 3.8 to 22 pts. and a corresponding increase in the case of Hen C.

The Pettenköfer titration method was used to obtain results given in Table II. Samples were taken by filling 500 c.c. flasks with distilled water and allowing it to drip out slowly,

* Note Bulletin 102.

Table No 2.

Parts by weight of carbon dioxide in 10,000 parts of air.

	Hens A	B	C	Barn
July 5	37.9	10.1	12.0	—
July 11	21.7	27.5	7.3	3.6
July 13	10.8	9.0	7.2	3.6
July 15	22.0	14.7	5.3	3.6
July 17	40.6	12.9	5.5	5.5
July 19	46.0	9.3	5.6	3.7
July 22	66.5	38.8	9.2	5.5
July 24	54.8	32.8	5.4	—
July 26	80.1	46.7	11.2	3.6

the time consumed being as near 15 minutes as it was possible to adjust the apparatus to this rate of flow.

Hen A had a nest made of earth covered with a thin layer of hay, while the other two hens had a nest of hay. Hen A

Table No. 4.

Parts by weight of carbon dioxide in 10,000 parts of air.

Incubator No.	11	18	19	Cellar Air
Feb. 27	4.8	—	—	4.3
Feb. 28	9.6	9.6	—	11.8
March 1	8.7	—	—	—
March 2	10.3	10.5	—	—
March 4	7.8	9.7	—	5.8
March 5	10.7	12.3	—	8.8
March 6	14.3	9.5	—	8.1
March 7	14.7	10.8	7.8	6.8
March 8	18.6	14.5	8.7	13.5
March 9	15.5	15.5	7.8	8.7
March 10	16.8	11.6	8.7	7.7
March 11	21.2	18.3	12.5	8.7
March 12	24.2	21.3	16.5	11.6
March 13	26.9	20.2	26.3	9.5
March 14	31.0	23.5	20.6	18.6
March 15	20.2	21.2	12.5	8.2
March 16	29.5	21.9	17.1	11.4
March 17	25.0	22.1	19.2	9.2
March 18	26.1	23.2	18.4	8.8
March 19	—	28.0	23.2	8.7

and B had good eggs and Hen C china eggs. The rubber tubes through which the air was drawn, were fixed permanently in the box and passed into wooden nest eggs through which a hole was bored. This was kept near the center of the nest and the hen did not have to be disturbed when the sample was drawn.

The greatest trouble was the movement of the hen on the nest if the taking of the sample occupied a long period of time. Here again we see the increase of CO_2 during the incubation period but not so markedly as in Table I.

In the case of the hen with china eggs there is no increase of CO_2. During this period a few sample were drawn through potash bulbs with results as shown in Table III. The time occupied to draw 1,000 c.c. being about 3 hours. This method confirmed the results already given, but with higher readings in some cases. A sample from Hen C taken in this way gave 4.5 pts. This confirms the results already obtained for a hen without good eggs.

TABLE III.

(Hen A.)

July 22,	133	pts.	carbon	dioxide	in	10,000	of	air
" 23,	96.3	"	"	"	"	"	"	"
" 25,	46.4	"	"	"	"	"	"	"
" 26,	74.0	"	"	"	"	"	"	"

Table IV is typical of results obtained from a number of tests with incubators. The samples were drawn with an aspirator from over the egg tray. Samples drawn from beneath the tray corresponded with those from above the tray. Incubator 11 was a Cyphers and Incubators 18 and 19 were the Prairie State. In No. 18 oats were sown in a pan containing earth which is placed beneath the egg tray. The oats were sown to test the effect on the air of the incubator of the CO_2 given off by sprouting seed. No noticeable difference was found in the air of the two incubators.

Here we see the increase of CO_2 in Incubator II from 4.8 to 29.5 pts. In Incubator 18 there is an increase from 9.6 to 28 pts. There is a corresponding increase in Incubator 19. This table shows the increase in the amount of CO_2 to be due to the growth of the chick in the egg. This CO_2 comes from the network of capilaries which lie just under the shell and is produced by the life processes taking place within the egg.

Meteorological Observations at Storrs for the Year 1905.

GENERAL WEATHER AND CROP REVIEW.

By W. M. Esten.

Latitude 41° 48′, longitude 72° 16′, elevation 640 feet.

The present report contains data taken from seventeen years of continuous records. This average of weather gives a fair representation of the climate of Storrs.

Table 1 gives the observations taken for the year 1905. The mean temperature for the year was 46.8° which is remarkable for being the average for the past seventeen years. The mean temperature for the state was 47.4°. There is about 5° difference in the mean temperature between the northern and southern boundaries of the state. The highest mean temperature, 49.7°, was at Bridgeport. The coldest parts of the state are at the northwestern corner and in eastern Tolland County, with a mean temperature of 45.8°. The highest record for the state was 98° at Bridgeport on July 18. The year commenced with low temperatures for January and February, the former being 3.2° and the latter 5.8° below the average for each month for the past seventeen years. The other months had very small departures from the normal except December which was 3° above the average.

The rainfall for the year was 36.14 inches, 10.83 below the average of 17 years and 4.62 inches below the average for the state. The variation of rainfall in the state is well shown in Table 2. In general the low areas receive less precipitation than high areas up to 4,000 feet, above this the amount of precipitation decreases. The highest point where observations are taken is Cream Hill, which had the maximum rainfall for the year of 45.75 inches; North Grosvenor Dale and the least, 35.75 inches.

The growing season commenced on the 23d of April, the date of the last killing frost and lasted until the 27th of September, the date of the first killing frost, a period of 156 days, nine days above the average which is 147 days. The average date for the last killing frost in spring is May 7 and October 2 for the first killing frost.

The weather for January and February was extremely cold. The month of March was warm and pleasant. Spring birds made their appearance and the croaking of frogs was heard earlier than usual. By the end of the month in the southern parts of the state, considerable planting of vegetables had taken place. April was normal in weather conditions. May and June were cold months with disagreeable winds and cold nights. May was a dry month while June had more than the average of rainfall. General crops were very backward and a good many had to be replanted. Rye, oats and hay, however, made a phenomenal growth with large harvests. July was a good growing month and crops made good advances. August and September were rather cool months. October, November and December were characterized by fine fair weather with abundance of sunshine. November was deficient in rainfall. December was remarkable for mild sunny weather. In southern sections of the state the ground was free from frost. In parts of Rhode Island and Connecticut plowing was in progress during some portion of each week during the month. The weather was very favorable for all kinds of outdoor work.

The following tables are self explanatory, two of which have been referred to. Table 7 is a new one intended to show the comparisons of variations from the mean or normal conditions of the weather and climate at Storrs.

TABLE No. 1.

Meteorological observations for 1905.

Temperature	January	February	March	April	May	June	July	August	September	October	November	December	Total	Mean
Highest.....	49	43	76	72	81	85	91	86	81	77	62	58	—	71.7
Lowest.....	−1	−5	5	24	37	41	51	43	32	23	10	5	—	22.1
Mean.......	21	19	34	45	57	64	71	66	60	54	38	33	—	46.8
Total precipitation, inches.....	3.57	1.21	3.45	2.87	0.90	4.53	1.77	2.63	5.79	2.57	2.73	4.12	36.14	—
No. days with .01 in. or more precipita'n.	5	2	5	5	4	6	5	9	7	5	6	5	64	—

TABLE No. 2.

Rainfall during growing season, May 1 to October 31, 1905.

Locality	Observer	Inches per month						Total
		May	June	July	August	September	October	
Bridgeport.....	Wm. Jennings..	0.91	4.30	13.04	4.66	6.16	2.48	31.55
Canton........	G. J. Case......	0.93	3.77	4.22	4.10	5.41	2.68	21.11
Clark's Falls....	E. D. Chapman.	2.13	4.25	1.64	6.91	6.98	—	—
Colchester......	S. P. Willard...	1.82	5.52	2.26	4.10	4.98	2.54	21.22
Cream Hill.....	C. L. Gold......	2.35	3.90	5.83	4.71	6.83	2.90	26.52
Danielson......	F. E. Bitgood...	1.41	3.42	1.18	2.76	4.33	—	—
Falls Village....	M. H. Dean.....	—	2.91	4.79	3.79	6.51	3.11	—
Hartford.......	Weather Bureau	1.25	4.85	2.71	5.08	3.43	2.23	19.55
Hawleyville....	E. N. Hawley...	1.24	4.02	5.12	5.96	3.13	2.88	22.35
Lebanon.......	E. A. Hoxie....	1.25	5.23	2.16	4.08	4.76	2.72	20.20
Madison.......	J. D. Kelsey....	1.38	5.70	3.53	5.48	4.30	1.71	22.10
New Haven....	Weather Bureau	1.18	5.87	2.86	7.20	5.07	2.21	24.39
New London...	T. C. Dillon.....	1.31	5.72	2.76	5.12	3.54	2.27	20.72
N.GrosvernorD.	Grosvenor D.Co.	1.52	3.93	0.76	4.03	5.88	1.83	17.95
Norwalk.......	G. C. Comstock..	0.69	2.85	3.91	7.37	7.53	2.69	25.04
Southington....	L. Andrews.....	1.45	4.90	2.95	4.75	4.05	1.50	19.60
S. Manchester..	K. B. Loomis...	0.77	4.64	2.13	5.14	2.94	2.13	17.75
Storrs.........	Agr. Ex. Station	0.90	4.53	1.77	2.63	5.79	2.57	18.19
Torrington.....	Prof.E.H.Forbes	1.13	3.68	4.13	4.69	5.11	2.73	21.47
Voluntown.....	Rev.E.Dewhur't	1.76	5.81	1.58	4.23	6.42	2.46	22.26
Waterbury.....	N. J. Welton...	1.27	4.22	4.20	5.65	4.27	2.50	22.11
W. Simsbury...	S.T.Stockwell .	0.83	3.53	—	3.83	4.76	2.15	—
Average.....		1.30	4.43	3.40	4.83	5.10	2.41	21 89

TABLE NO. 3.

Summary of rainfall for growing season, May 1 to October 31, for twenty places in Connecticut for past 16 years.

Year	Highest	Place of Occurrence	Lowest	Place of Occurrence	Average of Twenty Localities
1889	37.38	New Haven.....	28.64	N. Woodstock...	32.41
1890	31.87	Canton.........	24.89	New London.....	29.07
1891	23.11	Franklin........	14.91	Waterbury......	19.59
1892	29.06	Falls Village....	14.12	N. Franklin.....	19.67
1893	28.70	Oxford.........	18.31	New London.....	24.32
1894	24.35	New Hartford...	15.69	Lake Konomoc..	19.79
1895	25.66	Voluntown......	17.01	Newington......	21.63
1896	26.19	Falls Village....	16.99	New London.....	22.30
1897	39.78	Southington.....	23.46	New London.....	30.84
1898	34.88	Voluntown......	23.87	Winchester......	29.54
1899	25.69	Canton.........	15.04	New Haven.....	19.34
1900	31.08	Falls Village....	12.40	New Haven.....	19.65
1901	33.11	Waterbury......	16.20	New London.....	27.80
1902	35.40	Cream Hill.....	17.23	New London.....	27.21
1903	34.45	Hawleyville.....	16.13	New London.....	25.78
1904	28.47	Cream Hill......	17.04	New London.....	22.93
Avg.	30.57		18.25		24.49

Table No. 4.

Monthly mean temperature for past 17 years.

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual Mean
1888	——	——	——	——	——	65.3	66.4	67.3	57.1	43.8	39.7	30.0	——
1889	30.8	22.1	34.9	45.6	58.4	65.2	67.9	64.8	59.7	45.8	40.9	35.1	47.6
1890	32.0	31.7	30.8	44.7	54.9	63.3	67.5	66.0	59.5	47.6	37.9	23.4	46.6
1891	28.8	29.3	31.9	46.1	54.1	63.9	65.2	68.4	63.7	48.3	38.2	37.0	47.9
1892	25.5	26.9	29.9	44.9	53.6	67.0	69.2	67.4	59.1	48.5	37.6	25.5	46.3
1893	17.3	23.5	30.3	42.0	54.5	64.2	67.9	68.0	55.9	51.7	38.1	27.8	45.1
1894	27.7	23.0	38.6	44.7	56.4	66.0	70.9	65.8	63.0	50.6	34.1	28.2	47.4
1895	24.4	19.9	31.1	44.1	57.3	66.6	66.1	68.3	63.1	45.0	41.7	32.6	46.7
1896	21.8	26.3	28.5	47.5	59.9	63.2	69.6	68.5	59.9	47.2	43.5	26.8	46.9
1897	25.0	27.0	34.0	46.0	56.0	62.0	69.0	66.0	60.0	51.0	39.0	31.0	47.2
1898	25.0	28.0	40.0	42.0	54.0	64.0	70.0	69.0	63.0	52.0	38.0	29.0	47.8
1899	25.0	22.0	31.0	45.0	56.0	67.0	68.0	67.0	59.0	52.0	39.0	31.0	46.8
1900	27.0	26.0	30.0	46.0	55.0	66.0	71.0	69.0	64.0	54.0	41.0	29.0	48.2
1901	25.0	19.0	33.0	45.0	54.0	67.0	71.0	66.0	62.0	50.0	33.0	29.0	46.2
1902	24.0	25.0	41.0	46.0	55.0	64.0	66.0	66.0	59.0	48.0	44.0	23.0	46.8
1903	26.0	27.8	43.1	45.9	58.8	59.3	68.0	61.7	60.8	51.1	35.8	23.3	46.8
1904	18.0	18.6	34.1	42.9	59.7	63.4	68.7	65.9	59.9	48.1	35.6	22.4	44.8
Average	25.2	24.8	33.9	44.9	56.1	64.6	68.4	66.2	60.5	49.1	38.7	28.5	46.8

TABLE No. 5.

Total monthly precipitation for past 17 years.

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual Precipitation
1888	——	——	——	——	——	2.10	1.93	4.97	8.45	6.35	4.94	5.28	——
1889	4.03	1.64	1.96	3.49	2.16	3.50	11.39	3.78	4.00	5.52	5.91	2.88	50.26
1890	2.66	3.28	6.12	3.15	6.33	2.79	2.81	4.26	7.19	5.25	.82	4.21	48.87
1891	8.52	5.64	4.42	3.51	2.50	1.84	4.96	3.95	4.08	4.14	3.09	4.96	51.61
1892	4.91	1.60	3.00	.70	5.60	2.77	3.25	5.20	1.40	1.09	5.41	1.35	36.28
1893	2.39	5.88	4.67	3.82	7.12	1.98	1.58	3.79	2.58	6.71	2.45	3.68	46.65
1894	2.24	3.13	1.18	2.67	3.58	.59	2.09	2.37	3.01	4.16	4.00	4.31	33.33
1895	5.78	.63	2.62	4.27	2.16	1.78	4.13	3.48	2.97	6.74	6.97	4.12	45.65
1896	1.60	7.10	4.86	.80	2.72	1.78	3.22	2.71	7.03	3.60	2.49	2.67	40.58
1897	3.84	3.40	3.66	2.37	4.44	2.79	12.24	5.23	1.39	.92	7.14	5.61	53.03
1898	4.70	4.03	3.09	4.44	3.81	2.48	6.24	5.87	2.22	6.18	6.11	1.96	51.13
1899	3.76	3.97	5.58	2.20	1.17	3.72	5.55	3.27	3.31	1.54	2.10	2.14	38.31
1900	3.42	7.31	6.43	2.67	4.91	4.32	2.76	2.03	2.27	3.21	6.79	2.22	48.64
1901	8.50	1.05	7.18	9.51	6.30	1.96	5.54	7.58	4.33	1.97	3.04	9.55	66.51
1902	2.53	5.11	6.35	3.81	1.73	3.25	7.48	2.17	7.05	5.68	1.10	5.86	52.12
1903	3.73	5.18	7.09	2.81	.50	9.24	4.56	4.52	1.81	2.79	1.95	4.27	48.45
1904	4.55	2.80	3.31	6.40	1.96	2.53	1.85	6.00	4.71	2.19	1.47	2.42	40.19
Average	4.20	3.86	4.47	3.54	3.56	2.91	4.80	4.19	3.99	4.00	3.87	3.97	46.97

TABLE No. 6.

Growing season for past 17 years.

Year	Last Killing Frost, Spring	First Killing Frost, Fall	Growing Season
1888	May 16	September 7	114 days
1889	May 4	September 23	142 "
1890	April 29	September 25	148 "
1891	May 5	October 17	164 "
1892	April 30	September 21	144 "
1893	May 8	October 17	161 "
1894	May 15	September 26	134 "
1895	May 17	October 15	150 "
1896	May 2	September 24	144 "
1897	April 22	September 28	159 "
1898	May 10	October 17	160 "
1899	May 4	September 15	134 "
1900	May 11	October 18	158 "
1901	May 6	September 26	142 "
1902	May 28	October 10	135 "
1903	May 3	October 15	165 "
1904	April 24	September 22	150 "
Average			147 days

TABLE NO. 7.

Grand Summary for 17 years at Storrs.

Temperature		Date	
Mean	46.8°		
Highest	96°	July 5	1898
Lowest	13.3°	February 17	1896
Highest annual mean	48.2°		1900
Lowest annual mean	44.8°		1904
Range of	109°		
Greatest daily range of	46°	December 23	1902
Range of annual mean	3.4°		
RAINFALL			
Mean	46.97 in.		
Greatest annual	66.51 "		1901
Least annual	33.33 "		1894
Greatest monthly	12.24 "	July	1897
Least monthly	.50 "	May	1903
Greatest daily	4.26 "	June 21	1903
GROWING SEASON			
Longest duration of	165 days	May 3 to Oct 15	1903
Shortest duration of	114 "	May 16 to Sept. 7	1888
Average date of last killing frost in spring		May 7	
Average date of first killing frost in autumn		October 2	
Prevailing wind	Jan., Feb., March, Apr., Aug., Oct., Nov., Dec.,		N. W.
Prevailing wind	June, July, Sept.		S. W.
	May		W.
	For the year		N. W.

Meteorological Observations at Storrs for the Year 1906.

GENERAL WEATHER AND CROP REVIEW.

By W. M. Esten.

Latitude 41° 48′, longitude 72° 16′, elevation 640 feet.

Observations have been taken for the past eighteen years. The data of each succeeding year added to the previous total data gives a more valuable and correct average of the climate in this locality.

TEMPERATURE.

The mean temperature for the year was 48.1°, 1.1° above the average. The mean for the state was 49.1°. The year commenced with very mild weather in January and February, the former 6.2° and the latter 3.2° above the average. This shows a marked contrast with the temperatures of these months in 1905, which were respectively 3.5° and 5.8° below the normal. March was a very cool month with instances of zero weather. The wind velocities were more than usual, attaining a rate of sixty miles an hour in the principal storms. April had a mean normal temperature, but marked departures in extremes of temperature. The lowest maximum summer temperature in the state was at Storrs with 89°. The annual range of temperature of 92° is the least in the state including Colchester. Cream Hill in the western part of the state and situated on the highest elevation had the lowest temperature of eleven below zero and the greatest range of 103°. Storrs has the most equable temperature and is therefore one of the most healthful localities in the state. The summers are delightfully cool and the winters milder than most parts of the state.

RAINFALL.

The total amount for the year of 43.63 inches was 3.34 inches less than the average for the past eighteen years. June on the average has the least rainfall of 2.93 inches for the past eighteen years, while July has the greatest amount of precipitation with an average of 4.98 inches. This fact about July is really anomalous because in 1889 over 11 inches, and in 1897 over 12 inches of rain fell in the month of July. These amounts of rain in a single month are phenomenal and make the average too high. The month of the most storms is March with theoretically the most rainfall. For the year the first two and last two months with June, August and September all had less than their average amount of precipitation. November had the greatest deficiency of 2.05 inches. August was next with 1.67 inches less than normal. March and April had about 1.50 inches and May 2 inches more than the normal. The average for the state was 46.25. The variation of the amount of rainfall over the different parts of the state is interesting. There are two kinds of variations; first, a permanent variation whereby the western part of the state receives the maximum amount and the eastern part the minimum; second, a local variation where certain areas of the state receive for one season only, either very much more or very much less than the normal average. These local variations seem to have no law controlling them, but happen to vary from causes as spasmodic as the rainfall. Moisture laden winds always precipitate more rain moving up and over elevations of land than when blowing over level areas or down descending slopes.

GROWING SEASON.

The growing season commenced at the last killing frost on May 11th and extended to the first killing frost on October 12th, a period of 154 days, 7 days longer than the average of

147 days. The last and first killing frosts were from four to ten days respectively later than they commonly occur.

Of the thirty cold waves which passed across the state, five each were in November and December, three each in February, March and September, two each in January, April and October, one each in May, June and August. The cold wave of March 24 was remarkable for temperatures below zero. At Canton and North Grosvenordale it was the coldest period of the entire year with temperatures 6° and 3° below zero respectively.

TABLE No. 1.

Meteorological observations for 1906.

Temperature	January	February	March	April	May	June	July	August	September	October	November	December	Total	Average
Highest	68	54	52	73	87	86	84	89	87	73	65	52		72
Lowest	0	−2	2	17	31	39	48	51	37	28	19	−3		22
Mean	32	27	29	46	57	65	70	71	64	52	40	26		47
Total precipitation, inches	3.16	2.68	5.46	4.40	5.87	2.18	5.03	2.16	2.65	4.85	2.39	2.80	43.63	
No. days with .01 inch or more precipitation	9	3	9	7	7	6	8	4	7	5	6	8	79	

TABLE NO. 2.

Rainfall during growing season, May 1 to October 31, 1906.

Locality	Observer	Inches per month						Total
		May	June	July	August	September	October	
Canton.........	G. T. Chase.....	4.43	2.48	7.80	3.19	3.01	5.63	26.54
Colchester......	S. P. Willard. . .	5.33	4.64	4.71	1.54	2.95	6.36	25.53
Cream Hill.....	C. L. Gold......	5.61	5.60	6.47	3.14	3.58	4.02	28.42
Danielson......	F. E. Bitgood...	4.69	6.10	1.89	2.00	1.98	2.77	19.43
Falls Village....	M. H. Dean.....	—	3.74	5.17	2.85	3.18	3.25	—
Hartford.......	Weather Bureau	4.60	2.19	5.09	2.65	3.57	5.54	23.64
Hawleyville....	E. N. Hawley...	4.21	5.32	6.83	2.17	2.90	4.54	25.97
Lebanon.......	E. A. Hoxie....	3.90	1.63	5.89	1.40	3.08	5.75	21.65
Madison.......	Jos. D. Kelsey..	4.85	4.35	6.40	.75	5.04	6.65	28.04
New Haven....	Weather Bureau	4.75	5.14	5.62	1.13	4.82	7.44	28.90
New London...	T. C. Dillon.....	5.34	5.90	6.41	2.10	3.17	7.42	30.34
N. Grosv'r Dale	Grosvenor D.Co.	6.46	3.10	3.96	1.96	2.04	4.08	21.60
Norwalk.......	G. C. Comstock.	4.87	1.90	4.96	3.09	3.02	5.66	23.50
Southington....	L. Andrews.....	4.80	4.05	5.00	1.90	2.35	6.05	24.15
S. Manchester..	K. B. Loomis...	5.17	2.45	5.08	3.27	2.74	4.27	22.98
Storrs.........	Agr. Ex. Station	5.87	2.18	5.03	2.16	2.05	4.85	22.14
Torrington.....	Prof.E.H.Forbes	4.87	2.31	5.93	2.30	3.22	5.53	23.16
Voluntown.....	Rev.E.Dewhurst	5.25	1.96	8.17	3.39	2.19	7.49	28.45
Waterbury.....	N. J. Welton....	3.74	4.83	5.49	2.71	1.92	6.26	24.95
W. Simsbury...	S. T. Stockwell..	4.24	1.96	7.38	1.80	3.29	5.75	24.42
Average......		4.89	3.59	5.66	2.28	3.00	5.46	24.93

Table No. 3.

Summary of rainfall for growing season, May 1 to October 31, for twenty places in Connecticut for past 17 years.

Year	Highest	Place of Occurrence	Lowest	Place of Occurrence	Average of Twenty Localities
1889	37.38	New Haven.....	28.64	N. Woodstock...	32.41
1890	31.87	Canton.........	24.89	New London.....	29.07
1891	23.11	Franklin........	14.91	Waterbury......	19.59
1892	29.06	Falls Village....	14.12	N. Franklin.....	19.67
1893	28.70	Oxford.........	18.31	New London.....	24.32
1894	24.35	New Hartford...	15.69	Lake Konomoc..	19.79
1895	25.66	Voluntown......	17.01	Newington......	21.63
1896	26.19	Falls Village....	16.99	New London.....	22.30
1897	39.78	Southington.....	23.46	New London.....	30.84
1898	34.88	Voluntown......	23.87	Winchester......	29.54
1899	25.69	Canton.........	15.04	New Haven.....	19.34
1900	31.08	Falls Village....	12.40	New Haven.....	19.65
1901	33.11	Waterbury......	16.20	New London.....	27.80
1902	35.40	Cream Hill......	17.23	New London.....	27.21
1903	34.45	Hawleyville.....	16.13	New London.....	25.78
1904	28.47	Cream Hill......	17.04	New London.....	22.93
1905	31.55	Bridgeport......	17.75	So. Manchester...	21.89
Avg.	30.57		18.15		24.34

TABLE No. 4.

Monthly mean temperature for past 18 years.

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual Mean
1888	——	——	——	——	——	65.3	66.4	67.3	57.1	43.8	39.7	30.0	——
1889	30.8	22.1	34.9	45.6	58.4	65.2	67.9	64.8	59.7	45.8	40.9	35.1	47.6
1890	32.0	31.7	30.8	44.7	54.9	63.3	67.5	66.0	59.5	47.6	37.9	23.4	46.6
1891	28.8	29.3	31.9	46.1	54.1	63.9	55.2	68.4	63.7	48.3	38.2	37.0	47.9
1892	25.5	26.9	29.9	44.9	53.6	67.0	69.2	67.4	59.1	48.5	37.6	25.5	46.3
1893	17.3	23.5	30.3	42.0	54.5	64.2	67.9	68.0	55.9	51.7	38.1	27.8	45.1
1894	27.7	23.0	38.6	44.7	56.4	66.0	70.9	65.8	63.0	50.6	34.1	28.2	47.4
1895	24.4	19.9	31.1	44.1	57.3	66.6	66.1	68.3	63.1	45.0	41.7	32.6	46.7
1896	21.8	26.3	28.5	47.5	59.9	63.2	69.6	68.5	59.9	47.2	43.5	26.8	46.9
1897	25.0	27.0	34.0	46.0	56.0	62.0	69.0	66.0	60.0	51.0	39.0	31.0	47.2
1898	25.0	28.0	40.0	42.0	54.0	64.0	70.0	69.0	63.0	52.0	38.0	29.0	47.8
1899	25.0	22.0	31.0	45.0	56.0	67.0	68.0	67.0	59.0	52.0	39.0	31.0	46.8
1900	27.0	26.0	30.0	46.0	55.0	66.0	71.0	69.0	64.0	54.0	41.0	29.0	48.2
1901	25.0	19.0	33.0	45.0	54.0	67.0	71.0	66.0	62.0	50.0	33.0	29.0	46.2
1902	24.0	25.0	41.0	46.0	55.0	64.0	66.0	66.0	59.0	48.0	44.0	23.0	46.8
1903	26.0	27.8	43.1	45.9	58.8	59.3	68.0	61.7	60.8	51.1	35.8	23.3	46.8
1904	18.0	18.6	34.1	42.9	59.7	63.4	68.7	65.9	59.9	48.1	35.6	22.4	44.8
1905	20.5	19.3	34.1	44.8	57.0	64.0	71.5	66.0	59.7	53.6	38.0	32.5	46.8
Average	24.9	24.4	33.9	44.9	56.2	64.5	68.6	66.7	60.5	49.4	38.6	28.7	46.8

TABLE NO. 5.

Total monthly precipitation for past 18 years.

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual Pre-cipitation
1888	——	——	——	——	——	2.10	1.93	4.97	8.45	6.35	4.94	5.28	——
1889	4.03	1.64	1.96	3.49	2.16	3.50	11.39	3.78	4.00	5 52	5.91	2.88	50.26
1890	2.66	3.28	6.12	3.15	6.33	2.79	2.81	4.26	7.19	5.25	.82	4.21	48.87
1891	8.52	5.64	4.42	3.51	2.50	1.84	4.96	3.95	4.08	4.14	3.09	4.96	51.61
1892	4.91	1.60	3.00	.70	5.60	2.77	3.25	5.20	1.40	1.09	5.41	1.35	36.28
1893	2.39	5.88	4.67	3.82	7.12	1.98	1.58	3.79	2.58	6.71	2.45	3.68	46.65
1894	2.24	3.13	1.18	2.67	3.58	.59	2.09	2.37	3.01	4.16	4.00	4.31	33.33
1895	5.78	.63	2.62	4.27	2.16	1.78	4.13	3.48	2.97	6.74	6.97	4.12	45.65
1896	1.60	7.10	4.86	.80	2.72	1.78	3.22	2.71	7.03	3.60	2.49	2.67	40.58
1897	3.84	3.40	3.66	2.37	4.44	2.79	12.24	5.23	1.39	.92	7.14	5.61	53.03
1898	4.70	4.03	3.09	4.44	3.81	2.48	6.24	5.87	2.22	6.18	6.11	1.96	51.13
1899	3.76	3.97	5.58	2.20	1.17	3.72	5.55	3.27	3.31	1.54	2.10	2.14	38.31
1900	3.42	7.31	6.43	2.67	4.91	4.32	2.76	2.03	2.27	3.21	6.79	2.22	48.64
1901	8.50	1.05	7.18	9.51	6.30	1.96	5.54	7.58	4.33	1.97	3.04	9.55	66.51
1902	2.53	5.11	6.35	3.81	1.73	3.25	7.48	2.17	7.05	5.68	1.10	5.86	52.12
1903	3.73	5.18	7.09	2.81	.50	9.24	4.56	4.52	1.81	2.79	1.95	4.27	48.45
1904	4.55	2.80	3.31	6.40	1.96	2.53	1.85	6.00	4.71	2.19	1.47	2.42	40.19
1905	3.57	1.21	3.45	2.87	.90	4.53	1.77	2.63	5.79	2.57	2.73	4.12	36.14
Average	4.16	3.70	4.41	3.50	3.41	2.94	4.63	4.10	4.09	3 92	83.1	3.92	46.59

TABLE No 6.

Growing season for past 18 years.

Year	Last Killing Frost, Spring	First Killing Frost, Fall	Length of Growing Season
1888	May 16	September 7	114 days
1889	May 4	September 23	142 "
1890	April 29	September 25	148 "
1891	May 5	October 17	164 "
1892	April 30	September 21	144 "
1893	May 8	October 17	161 "
1894	May 15	September 26	134 "
1895	May 17	October 15	150 "
1896	May 2	September 24	144 "
1897	April 22	September 28	159 "
1898	May 10	October 17	160 "
1899	May 4	September 15	134 "
1900	May 11	October 18	158 "
1901	May 6	September 26	142 "
1902	May 28	October 10	135 "
1903	May 3	October 15	165 "
1904	April 24	Septebmer 22	150 "
1905	April 23	Septebmer 27	156 "
Average			148 days

TABLE No. 7.

Grand summary for eighteen years at Storrs.

Temperature	Amount	Date	
Mean	46.8°		
Highest	96°	July 5	1898
Lowest	13.3°	February 17	1896
Highest annual mean	48.2°		1900
Lowest annual mean	44.8°		1904
Greatest daily range	46°	December 23	1902
Range of annual mean	3.4°		
RAINFALL			
Mean	46.59 in.		
Greatest annual	66.51 "		1901
Least annual	33.33 "		1894
Greatest monthly	12.24 "	July	1897
Least monthly	.50 "	May	1903
Greatest daily	4.26 "	June 21	1903
GROWING SEASON			
Longest duration of	165 days	May 3 to Oct. 15	1903
Shortest duration of	114 "	May 16 to Sept. 7	1888
Average date of last killing frost in spring		May 7	
Average date of first killing frost in autumn		October 2	
Pervailing wind	Jan., Feb., March, Apr., Aug., Oct., Nov. & Dec.		N. W.
	May, June, July & Sept.		S. W.
For the year and most constantly	in February and November		N. W.

INDEX OF CUTS.

INDEX.

INDEX.